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For Occupational And Physical Therapy

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Chair: Prof. Sam Huang, Ph.D.
Prof. Richard Shell, Ph.D., P.E.
Prof. Woojin Park, Ph.D.
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George Kelley

Thesis Advisor And Committee Chair: Prof. Samuel Huang, Ph.D.
Abstract

The work introduces a new theoretical system designed to automate the scheduling of pediatric occupational therapy (OT) and physical therapy (PT) appointments across any number of regional service locations. The system automates the referral, evaluation, and treatment OT/PT careflow, and so scales the scheduling of appointments to the entire patient population at a time. The system selectively matches the patient's medical needs, the therapist's skillset, and the child patient's caretaker's weekday, time, and location appointment preferences. It uses multiple input channels operating under Separation Of Duties to gather decision-making intelligence, and a short-horizon, workload-balancing appointment request routing strategy to enqueue and roll-over appointment bookings. Five poll-sequenced and internally prioritized queues and the novel concept of softslots improve the odds of successfully booking a billable appointment. Simulations based on a case study showed that the new scheduling system improves patient access to care while it (a) preserves the therapist's discretion to change the patient's therapy plan based on the child's individual progress; (b) closely matches the patient's caretaker's appointment preferences and so reduces cancellations and no-shows; (c) improves the rate with which new patient referrals can be converted to billable evaluations and treatment plans; (d) more fairly and equitably distributes the patient caseload and paperwork among individual therapists; and (e) helps predict the smallest number of therapists needed at the hospital's main and multiple satellite locations.

Keywords: Patient Schedules, Therapist Workload, Hospital Occupational Therapy Department, Hospital Physical Therapy Department, Medical Workflow Optimization, Access To Health Care.
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This study was made possible by the generous access granted over the course of more than a year to a large, multiple-location OT/PT medical facility which specializes in the care of children.

I greatly admire the vision and courage of the leadership of the OT/PT facility to consider new ways to achieve continuous improvement in patient care, here by encouraging and enabling an exploration outside of the bounds and comfort of the status-quo. This study is just one example of their ongoing battle, now over many years, to keep its medical mission driving its daily functioning, and not the other way around.

I also much empathize with everyone's frustration over the barriers medical access caused by the injustices of scheduling inefficiencies caused by incomplete information and pre-authorization preoccupations, at times to the point of a child being denied for a lifetime the benefit an early medical intervention would have provided. This study thus aims to be transformational. It seeks to replace zero-sum thinking, one in which the few ink the checks to their fortunes with the blood of the many they deny, with win-win automated, electronic, transparent, scalable, and highly leveragable market driven workflow optimization and cost-containment model for pediatric OT/PT services.
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Chapter 1 - Introduction

This study helps develop a new patient scheduling system intended to automate the scheduling of child patients seeking therapy appointments with about 125 physical and occupational therapists (OTs and PTs). These therapists are based out of a large medical center which services a total of more than 25,000 OT/PT patient visits per year out of 10 area facilities. In such an environment, in a year's time, a manual scheduling optimization would have to evaluate and rank more than 4 billion different patient scheduling possibilities.

The child patients at the center of this study are a large and vulnerable part of society (Szilagyi, Shenkman, Brach, et al., 2003; Warfield and Gulley, 2006). About 9.3 million children, or 13% of all children in the United States, are children with a special health care need (Peters, 2005). Out of these, about 6 million children have a chronic disability which limits their childhood activities (Newacheck and McManus, 1998). One in every five households with children includes at least one child with a special health care need (Peters, 2005).

1.1 Barriers To OT/PT Patient Scheduling

There are significant barriers to the scheduling of OT/PT appointments, and particularly so for child patients with special needs (Callahan and Cooper, 2006). The
barriers are high because their needs are circumscribed by (a) an inherently greater need for medical services compared to reference child populations; (b) frequent illnesses, transportation woes, and the conflicting demands on their parents and guardians as their caretakers; (c) the fractured information about caretaker appointment preferences and therapist skillsets and locations available to the schedulers as their appointment stewards; (e) the billable time accountability of OTs and PTs as their caregivers; (f) managed authorizations tied to cost containment considerations on the side of third-party payors such as insurers and government health promotion programs as their financers; and (g) the productivity controls imposed by OT/PT facility managers as their cycle of care administrators.

1.2 Scheduling Implications

One implication of the facts observations just named is that any new OT/PT therapy appointment scheduling system must help reduce, and at the same time be tolerant of frequent no-shows and cancellations.

A second implication is that there has to be a carefully considered match between the medical needs of the patient, the scheduling preferences of the patient's caretakers, and the medical skills and work-hour limits of their caregiver therapists.

A third implication is that by automation, the mode and scale of OT/PT child patient can be changed to remove the significant barriers to access to OT/PT care currently imposed by the manual appointment filtering done by the referral specialist, caretakers, schedulers, therapists, payors, and administrators
1.3 Paradigm Shift Needed

To enable greater access to care in OT/PT settings, there is a need to convert more physician referrals, evaluation, and treatment requests as exist in the care pipeline into OT/PT medical therapy appointments that directly benefit the child patient. To meet the need, the approach used for the scheduling of OT and PT therapy appointment scheduling must be tolerant of change, selective in its matching, and resistant to filtering. There has to be a paradigm shift in thinking in OT/PT outpatient scheduling. The shift is to move away from booking individual appointments in an ad hoc fashion, as dictated by the micronetetic and disconnected demands of patients, caretakers, referral specialists, schedulers, therapists, payors, and administrators. And the shift is to move in the direction of automating the booking of OT/PT appointments for the entire special care child population as a whole, in a way that will optimize the setting of the individual therapy appointments by framing them within a larger context.

As demonstrated in this study, the new paradigm can be implemented by coordinating the roles of the patient, caretakers, referral specialists, schedulers, therapists, payors, and administrators by means of more abstracted interfaces designed to enable more structured patient-centered information gathering and the automated computer processing of a therapy schedule for the entire OT/PT patient case load population at a time.
1.4 Objectives

The main goal of this project is to help fill this need by initiating the development of an automated, optimizing, patient-centered scheduling system for a multiple-location hospital that can facilitate access to medical care on the part of children with OT/PT medical needs. The theoretical model for the new system seeks to make it easy to automate and optimize the scheduling of large numbers of OT/PT patients at a time.

More specifically:

1. Reduce the number of failures to evaluate and treat, and appointment cancellation, no-show, and patient abandonment rates, due to scheduling bottlenecks;

2. Shorten the time between the receipt of a patient referral, and the scheduling of the patient's evaluation and treatment sessions;

3. Facilitate the selective matching of the patient's primary diagnosis to a therapist with a suitable OT/PT designation and skillset specialization;

4. Increase the number of patients scheduled at the satellite facility and during the weekday time slots preferred by the child patient's parents and caretakers;

5. Improve continuity of care by preferentially scheduling the same therapist from the initial evaluation and through the completion of the entire OT/PT treatment plan;

6. Maximize billable therapist time face-to-face with a patient by freeing therapists from scheduling responsibilities, and thereby reducing distractions and frustrations, and improving therapist job satisfaction and retention;

7. Equitably distribute the patient case load into a more predictable and balanced daily therapist OT/PT appointment and paperwork man-hour commitment;
8. Fairly apportion and balance the OT/PT patient case load among all therapists and all satellite locations serviced by the regional hospital

9. Rationally predict and distribute the number and mix of therapists by OT/PT designation and skillset needed to service multiple therapy locations;

10. Generate reports that can be used as productivity drivers and control metrics from multiple perspectives and without requiring operator data input.

11. Enable greater access to care, as measured by increased conversion rates of physician referrals to billable evaluations, and of hosted evaluations to billable treatment sessions.

12. Change the scale and mode of pediatric OT/PT patient scheduling so that it can scale from individual appointment setting to the scheduling of entire OT/PT patient populations of patients at time.

Accordingly, in the chapters that follow, this study will first develop a patient-centered theoretical model for an OT/PT patient scheduling system that takes into account (a) the medical needs of child patients; (b) the scheduling preferences of the patient’s caretakers, their parents and guardians; (c) the specialization preferences and workload limitations of the therapists; (d) the need to optimize the utilization of multiple medical locations; and (e) the need for appointment transparency on the part of patient referral specialists, schedulers, payors, and administrators.
1.5 Approach

The solution approach uses (a) Separation of Duties to gather scheduling information from separate and independent information flow channels; (b) intelligent routing tied to prioritized appointment request and booked appointment queues; (c) rollover polling in combination with retrial queues; (d) a novel mechanism to improve the probabilistic availability of a given unused appointment slot; and (e) real-time computations of the therapist man-hour commitment.

The solution approach is capable of automating the creation of an OT/PT book of appointments for every patient scheduling frequency, daily, odd, weekly, every other week, or monthly, in a manner which fairly an equitably balances the patient case load distribution by therapist and location as new patient referrals arrive and the calendar advances through earlier OT/PT patient initial evaluation and follow-up treatment appointments.

Like channelized scheduling, the rollover polling approach differentiates patient appointment type and assigns them to channels. Each channel is given an order of precedence in the scheduling effort. Within each channel, the appointment requests are also rank sorted by age. Channel appointment that are not successfully booked are added to a retrial queue.

In contrast to channelized scheduling, the schedulers work in unison, in roll-polling mode. The intent is to improve the appointment throughput by preferentially flushing older patients out of the system before accepting new ones. The approach
provides for the escalation of OT/PT appointment requests in a manner that is suitable for
the automated scheduling of an entire OT/PT patient population at a time.

The study will also provide an example implementation in software to
demonstrate the population-level OT/PT appointment scheduling of the theory. The
software is used to run OT/PT patient scheduling simulations parameterized with data
from a year-long case-study at a large regional hospital which offers pediatric OT/PT
patient services by some 125 OT/PT therapists out of 10 different area service locations.

1.6 Outline Of Work

The work consists of six chapters.

This Chapter 1 has identified significant barriers to OT/PT patient scheduling,
described the scheduling implications of these barriers, and proposed that a new OT/PT
patient scheduling paradigm based on Separation of Duties can be implemented in a way
which can bypass these barriers and automate the processing of new OT/PT patient
referrals, evaluations, and treatments in a way that will service entire OT/PT patient case
load populations at a time.

Chapter 2 captures a picture of the child patient population in demographic,
medical, and financial terms. It then describes the current roles of (a) the child patient's
caretakers, (b) the hospital's in-house referral specialists, schedulers and therapists, and
(c) third-party payors and OT/PT facility administrators in meeting the therapy
scheduling needs of the child OT/PT patient. Chapter 2 also presents a review the
literature on medical appointment scheduling suitable for OT/PT practices. The review
demonstrates the need for the new approach to OT/PT patient scheduling proposed in this work.

Chapter 3 presents the conceptual model for the new OT/PT patient scheduling system. The approach is based on a novel patient-first, short-horizon, automated, prioritized queue polling appointment request and appointment booking roll-over model. The model makes use of (a) multiple independent input channels to gather and gain decision-making and appointment-booking intelligence, (b) workload balancing computations and the novel concept of softslots, and (c) routing intelligence built into five sequenced appointment request and appointment queues to auto-generate an updated schedule of appointments for the entire OT/PT patient case load population as the calendar advances. The model distributes the appointment load in a way that serves to meet (a) the medical needs of child patients; (b) the scheduling preferences of the patient's parents and caretakers; (c) the specialization and workload limitations of the therapists; (d) the billing expectations of third-party payors; and (e) the mission service and therapist and location utilization targets of administrators.

Chapter 4 describes a case study conducted on-site over the course of a year at the OT/PT division of a major regional hospital. The hospital has about 125 therapists, and provides OT/PT services at 10 different satellite locations. The case details the workviews associated with the hospital's AS IS OT/PT patient scheduling workflow. It describes the current means of processing new patient referrals from physicians, and the existing therapist-centered approach to the conversion of these referrals, one at a time, into OT/PT patient care and billable evaluation and treatment session schedules.
Chapter 5 details an experimental implementation of the forward-scheduling model described in Chapter 3 within the context of the case study presented in Chapter 4. It presents the new workviews associated with the TO BE patient load service and OT/PT patient population scheduling workflow, summarizes the results of simulation runs of the new OT/PT patient scheduling system when parameterized to fit the case study, and discusses operational, tactical, and strategic insights.

Chapter 6 summarizes the contributions of the study, outlines a new vision for OT/PT patient scheduling, and list several follow-up projects in need of funding.
Chapter 2 - Background And Literature Review

The scheduling of OT/PT patients involves many people. This chapter begins by providing some background about them. First, some brief demographic characteristics of the OT/PT child patient population of interest to this study are presented. There follows a short description of the roles played in pediatric outpatient OT/PT scheduling by the caretakers (parents and guardians), human schedulers, caregivers (therapists), payors, and OT/PT facility administrators. This initial information is important to the understanding of the many dynamic elements at work in the scheduling of an OT/PT child patient.

The chapter then advances by introducing some theory and terminology related to System Dynamics and queuing behavior. These underlie the solution approach presented in this study.

The chapter next lists a number of the existing approaches to outpatient OT/PT patient scheduling as described in the literature.

The chapter ends by drawing a set of conclusions which demonstrate the need and promise of the new approach to OT/PT outpatient patient scheduling introduced in this work.
2.1 Overview Of OT/PT Patient Scheduling Roles

There are seven key participants in pediatric OT/PT patient scheduling: (a) the patients, children all; (b) the patient's caretakers, their family and friends; (c) the referral specialists, who assign the patient's case to an OT or PT; (d) the schedulers, who book their OT/PT evaluation and treatment appointments; (e) those who fund the patient's OT/PT therapy, the payors, usually a third party; and (f) the administrators of the OT/PT facility where the patients obtain medical services. This section briefly describes their roles.

2.1.1 Patients First!

For many child patients with special health care needs, the medical condition for which they need OT/PT therapy will have already presented itself early in their lives. They may have been born premature, or have congenital conditions such as Down Syndrome, heart defects, or spina bifida. Others have conditions which express themselves only later, from developmental delays related to autism, cognitive development, and feeding. Respiratory and speech difficulties may also be present. Among the five most prevalent disabling medical conditions in such children are asthma, attention deficit disorder (ADD), diabetes, epilepsy, and cerebral palsy (Ireys, Anderson and Neff, 1996; Wolraich, Foster, Willis, et al., 1996). Statistical accidents such as playground mishaps and trauma from automobile wrecks also contribute to the large number of special care children in the population at large.
Special care children are 3 times as likely as other children to be ill (Peters, 2005). Incidentally then, they are also 3 times more likely to miss school, or any scheduled activity, including the scheduled OT/PT appointments that are at the core of this study. Given the long-term nature of OT/PT therapy, with appointments spread over weeks and months, or even years, the likelihood that a special care child will miss a scheduled appointment by virtue of an illness is high.

Special care children may seek medical services as hospital inpatients or ambulatory outpatients. As would be expected, their need for medical services is much greater than that of the child population at large (Peters, 2005). For example, they are hospitalized 3 times more often, and spend about 7 times as many days in the hospital (Newacheck and Kim, 2005). They also make 1.5 times as many visits to the emergency room, more than twice as many physician office visits, and almost 7 times as many non-physician visits as other children (Newacheck and Kim, 2005). This last number includes the scheduled visits to the OTs and PTs that are the subject of this study.

To meet their medical needs, special care children depend on the love of many. They rely on their family for encouragement and transportation. The referral specialist at the hospital must identify the type of therapist with the skillset that will best meet their needs. The scheduler must identify a specific therapist to service the OT/PT patient at the time and location preferred by the patient's caretakers. The therapist host their therapy session, and process their paperwork. Third-party payors, private insurers and government programs, pay for most of their medical services. For example, some 36 million children, about 45 percent of all children in families between 100% and 200% of the federal family poverty level, are covered by Medicaid (29.4 million) or the State
Children’s Health Insurance Program (SCHIP, 6.6 million) (Pear, 2007). Another 38% (30.4 million) are covered by private insurance, and some 17% (13.6 million) are uninsured (Pear, 2007). When not properly supported, these children are risk poor health outcomes and complications for themselves, their family, and society at large.

Transportation problems contribute to the high rates of skipped medical appointments on the part of outpatient special care children. Transportation woes have been shown to limit access to medical care (Whittaker, Adkins, Phillips, et al., 2004). Special care children may not be able to make it to a medical appointment simply because they lack transportation. As minors, they are invariably bound to the somewhat erratic and conflicted transportation services provided by their natural caretakers, their parents, guardians, in-laws, and other family members, when they need to be delivered to an OT or PT appointment. Alternate transportation options are limited by unsupportable costs, logistical snags, lack of government funding, fear of liability, and insurance-driven restrictions on the transportation of medical patients by commercial service providers.

By nature of their age alone, besides transportation, special care children invariably also lack a personal means of processing paperwork and making payment of medical services. They are dependent on the cash-flow management considerations of their caretakers and third-party payors when paying for the extended medical services they need (Newacheck and McManus, 1988). For example, parents eligible for coverage under Medicaid don't have to pay a co-payment when their children see a physician (Craig and O'Farrell, 2007). And less than 1 percent of inpatient hospital expenses and home health fees for special care children are paid out-of-pocket (Newacheck and
McManus, 1988). But these payments, subsidies, and re-imbursements depend on a review and approval process that excludes many.

2.1.2 Caretakers

Special care children are completely dependent on their caretakers, their parents, guardians, and family members, for appointment scheduling and transportation. As children, they are not able to schedule their own medical appointments or drive.

The caretakers often have to juggle multiple priorities and competing demands, such as employment, school, family, and daily living. These conflicts may and do interfere with the child's scheduled OT/PT therapy sessions. For example, the adult and the child are typically very limited in their options for the weekdays and times for a therapy appointment. They may only be able to come on Thursdays after 3 p.m. Or the caretaker may only have the time, or find it convenient to drive to a therapy location that is close to their job, home, or the child's school, less than 10 miles (Whittaker, Adkins, Phillips, et al., 2004). Once scheduled, the child patients need to be transported to their therapy sessions by an adult, typically a close relative. Events leading to OT/PT appointment cancellations and unanticipated no-shows may arise on many fronts. They may be due to an unrelated illness, or a disconnected issue faced by their caretaker. Work, leisure and sibling contention, and cash-flow considerations related to paydays and lack of bus-fare or money for gas and parking fees all play a role.

Faced with personal conflicts, transportation, and payment concerns, the caretakers of the special needs child may choose to delay OT/PT therapy for long periods
of time. In addition, they may be momentarily conflicted by work requirements, and
distracted by competing demands from the scheduled daily activities of other family
members. Others may find themselves unhappily resigned to the chronic condition of
their charge, and so shy from care as form of avoidance behavior.

Surprisingly, the literature show that only some 10% of special care children
experienced delayed or forgone health care in a 12 month period (Huang, Kogan, Yu, et
al., 2005). Delayed or forgone care was higher for adolescent special care children, and
those who had more severe activity limitations, lacked medical insurance, or lived in
families with incomes below statistical federal poverty cutoffs (Huang, Kogan, Yu, et al.,
Huang, 2005).

However, these data are hard to reconcile with long-standing field observations
that consider the socio-economic profile of the patient in question. Nearly 30 years ago,
adult clinics reported broken appointments rates of 15 to 33 per cent (Deyo and Inui,
1980). When made to feel un-welcome, the no-show rates for the poor and uninsured are
higher (Whittaker, Adkins, Phillips, et al., 2004). For example, in a study of an
ophthalmic child patient population, no-show rates were estimated to be only 5% for
"commercial patients," roughly 40% of the patient base (Guo, Wagner, and West, 2004).
In contrast, among the roughly 65% covered by Medicaid, the Medicaid and self-pay
patients had a 20% no-show rate for initial appointments and a 50% no-show rate for
follow-up appointments (Guo, Wagner, and West, 2004).

Today, according to estimates from the staff consulted in the case study related
herein, roughly 50% of all physician referrals for an initial OT/PT evaluation, and 30% of
all scheduled OT/PT treatment appointments, are never hosted or billed because the child
patient's caretaker did not follow up, cancelled at the last minute, or simply did not show up. The socioeconomic profile of the patients who do not show up is probably the same as those encountered by Guo, Wagner, and West (2004). Visitors who are not made to feel welcome do not return.

2.1.3 Referral Specialists

A referral is the process by which a physician recommends a patient for OT/PT therapy. The referral takes the form of a written medical prescription that is signed and dated by the physician. The prescription, like any other prescription, must be interpreted by a licensed specialist. In a pharmacy setting, this specialist would be the pharmacist. An OT/PT facility has a licensed specialist in a similar capacity, the referral specialist.

The referral specialist must interpret the prescription in a way that will identify the tentative primary medical diagnosis assigned to the patient by the physician. In an OT/PT setting, the intent of the interpretation is to assign a therapist with the skillset that can best meet the needs of the patient. The individual tasked with the interpretation of the physician's OT/PT prescription is the OT/PT referral specialist.

The referral interpretation process cannot be fully automated because the interpretation of the physician's prescription must take many factors into account that are specific to the patient's individual case. In particular, based on secondary medical characteristics presented by the patient, the needed skillset may be that of an OT or of a PT. In some cases, the services of both an OT and PT may be called for. In other cases, the referrals specialist may decide on neither because the patient's needs may be better
made by a different type of therapist, for example a speech therapist or, or behavioral counselor.

2.1.4 Schedulers

The schedulers are the office personnel tasked with scheduling actual OT/PT appointments. A day in the life of an OT/PT appointment scheduler is a study of tribulations in Jobian proportions.

After the referral specialist has inferred an initial primary billable diagnosis and assigns the case as either being more appropriately assigned to either an OT or PT (or both), the physician's referral is logged, and handed to the scheduler.

The scheduler then attempts to contact the child's caretaker to discuss appointment options and obtain payment information. The percentage of children with private insurance or government entitlement program coverage is also reported in the literature as actually being higher than for the child population at large (Peters, 2005). In such cases an insurance company or government agency must then be contacted by the scheduler or other back-office personnel to verify eligibility for services and obtain authorization for services and re-imbursement routing. The third-party entity may be under contract with the hospital, and so the type and quantity of services, and amount re-imbursed, may have been pre-negotiated, and only needs to be confirmed. At other times, extensive pre-approval documentation processing may be needed. The actual amount paid by different payors is highly variable (Mason, 2007).
With the payment options in place, the scheduler next attempts to contact the child's caretaker again to schedule the OT/PT appointment. Multiple attempts may be needed before the scheduler is able to determine the caretaker's preferences for an OT/PT appointment. As warranted by the occasion, the scheduler has to schedule one of two types of OT/PT appointments: an initial evaluation, or a subsequent series of treatment sessions. As will be discussed later, the differentiation is transparent to the patient and scheduler, but important to the therapist assigned the appointment.

Once the scheduler has been able to match the caretaker request to an available therapist, the scheduler then finalizes the appointment by identifying a specific therapist, either an OT or PT, as determined by the interpretation of the patient's initial referral slip, who is available at the location and during the time slot sought by the caretaker. Importantly, although licensed to serve all conditions within their OT or PT designation, the therapist assignment made by the scheduler must take into account the professional interest and prior experience with the sub-specialization within their OT or PT designation needed to best serve the patient's specific case. This skillset information however is not usually immediately available to the scheduler in a formal document, and must instead be captured from the experience gained from previous patient scheduling efforts.

After all this work, which may take a month and countless hours of un-reimbursed staff time, the scheduler and the rest of the back-office team may still end up with a last-minute cancellation or no-show, and have to start anew. Last minute cancellations and no-shows are as much of a problem for the hospital as they are for the scheduler. Therapy sessions are typically only billable if actually held face-to-face between the
OT/PT and the patient. A cancellation typically comes too late for the scheduler to be able to rebook it with another patient. A no-show deprives the hospital of compensation for the direct and overhead costs incurred in making the scheduler, the back-office personnel, and the therapist available.

The scheduler's appointment-setting options are determined by the overlap between the caretaker's location, weekday, and daytime preferences, and the therapist's OT/PT designation, sub-specialization, location, and number of previously booked appointments. When looking at the patient, the scheduler's options are limited by two items.

The first one is the inability of the patient's caretakers provide timely and meaningful information to the scheduler over the phone for lack of advance knowledge that they would unfold.

The second one is the inability of the scheduler to record and capture this information for use and re-use by an automated scheduler.

Conversely, when looking at the therapist, the scheduler is limited to whatever information is available about the medical specialization and current booking availability of therapists. This information is all too often incomplete or outdated, if not missing entirely.

Clearly, special care children pose some unique scheduling challenges to OT/PT appointment schedulers:

- Appointments can only be initiated after a referral slop from a physician has been processed, and often only after advance payor authorization has been received;
• There has to be a close match between the medical needs of the patient and the licensed OT/PT designation, and secondary medical skillset of the therapist;

• It is difficult for the scheduler to apportion the incoming patient scheduling workload fairly and evenly among all available therapists because initial evaluations and follow-up treatment sessions impose very different preparation and paperwork and man-hour commitment burdens on the assigned therapist;

• Continuity of care considerations mandate that the same therapist who hosted an initial evaluation or initiated a treatment plan stay with the patient for the duration of their intervention plan;

• Child patients must often attend therapy sessions that vary in duration and intensity depending on their progress within their medical condition and their natural growth and development;

• For therapeutic reasons, the OT/PT sessions often must be scheduled to be spaced and repeated on a regular basis, typically weekly, but sometimes more or less frequently, like daily or monthly;
- OT/PT appointment sequences can last for weeks and months on end, and so sooner or later must be rescheduled due to holidays, therapist and family vacations, other illnesses, and the daily vicissitudes of life, such as bad weather;

- Once begun, the frequency and duration of the OT/PT therapy appointments may be extended or curtailed, based on the therapists' observations and the child's progress;

- The OT/PT appointment must take into account the often very specific location, weekday, and daytime preferences of the patient's caregivers, and obtaining this information on preferences and confirmation of appointments requires multiple phone call attempts and must be repeatedly updated.

Face with balancing all of these considerations, the scheduler nonetheless has to take advantage of the moment, and schedules an appointment when the opportunity presents itself. Unfortunately, after being cornered into making poor individual matches repeatedly, the overall result from the thankless travails of the OT/PT appointment scheduler is to leave everyone, the child patient, the caretakers, the caregivers, the payors, and the hospital administration with an unsatisfactory OT/PT appointment schedule. In addition, instead of welcoming an earlier appointment at the hospital's main facility, the vast majority of caretakers are reported by the staff to be willing to wait more than four weeks for an appointment at a satellite location that is more convenient to them, and closer to their place of employment, home, or the school they children attend.
Sadly, the unsatisfactory schedule has more far-reaching consequences beyond incurring frustration and unproductive costs. Vexed by the daunting prospect of undertaking yet another protracted scheduling round with the hospital scheduler, including tape-recorded phone-trees, missed phone calls, and tiring voice-mail exchanges, the caretaker may significantly delay seeking help, and even give up entirely. The child patient then stands abandoned, denied access to medical care that would have improved their quality of life and that of their friends and family, as well as reduced the life-time costs associated with their care.

2.1.5 Therapists

The medical care needs of special care children is met by a sizable team of clinical specialists offering a full spectrum of medical care. The members of this team are the patient's caregivers. They specifically licensed by the state in which they practice to perform their specialized professions. They are highly credentialed and must meet continuing training requirements and abide by standards of professional ethics. The team includes pediatricians, consulting specialists, psychologists and speech therapists. Licensed social workers are also often involved.

This study narrowly considers only two specialized medical practitioners within the comprehensive continuum of care offered by all member of the caregiver team: the occupational therapists (OTs) and physical therapists (PTs). For simplicity, in this work the OT and PT therapists are considered to be the patient's only caregivers. In it just important to understand that in reality they do not function in isolation.
As presented earlier, the medical intervention by an OT or PT as the patient's caregiver may arise from medical conditions existing at birth, or motor or cognitive medical issues related to physical, intellectual, and emotional development, family histories, or accidents. Because OTs and PTs consider the full range of physical, affective, cognitive and environmental components of growth, illness, and injury, their credentialing requirements for licensing as an OT or PT are considerable. The requirements include years of specialized formal education to the level of a Master's degree. The credential is a medical one, on a par with the medical credentialing required of nurses and physicians, and is similarly subject to renewal reviews. In the U.S., much of guidance on the professional education and credentialing of OTs is offered by the American Occupational Therapy Association. The American Physical Therapy Association serves a similar role for PTs.

In general terms, OT's perform help the patients develop adaptive coping techniques to enable them to improve their ability to perform ordinary daily activities of living, like holding a fork or remembering things. OTs are often called on to improve the quality of life of a patient following birth injuries or the loss of motor or mental function resulting from damage to the spinal cord or a brain injury. OTs also address evidence of learning and mental health difficulties, visual, perceptual or cognitive impairments, or developmental disabilities such as autism or cerebral palsy. Besides helping the patient directly, OT's also make recommendations for the adaptation of household or office doors, bathrooms, furnishings and utensils.

PTs are primarily concerned with treatment techniques that promote the ability to move, restore range of motion and dexterity, and reduce joint pain. They seek to prevent
the escalation of a motor disability caused by unfavorable musculo-skeletal, cardio-pulmonary, or neurological conditions. PTs help patients open doors and climb stairs. They offer technique training on the proper usage of limb braces, walkers, or wheelchairs. Besides movement enhancement, they can use physical, electrotherapeutic and mechanical means to minimize scarring from wounds, improve posture to reduce back and neck pain, and regain limb control following sport-related injuries or a stroke.

Both OTs and PTs in a child patient setting are really responsible for two patients. They offer medical guidance, encouragement, and support to the child's caretakers and as much as they do directly to the child. This dual relationship and accountability bond makes the medical efforts of the therapists critically dependent on both the effectiveness of the therapist's clinical training as well as their people and communication skills.

As can be imagined, OTs and PTs as a result are generally a difficult and expensive resource for a hospital to recruit, and a valuable but skittish one to retain, be they employees or independent contractors. The average yearly pay of OTs and PTs is in the mid-50's to mid-70's, but does vary considerably and is often much higher depending on experience, specialty, hours worked, the geographic location of the work, and local employment market conditions (payscale.com, 2007).

OTs and PTs conduct two types of therapy sessions, evaluations and treatments. Both evaluations and treatments are typically scheduled to begin at the top of the hour and last 30 or 45 minutes. From a scheduling perspective, it is important to note that the time spent with paperwork, and cancelled appointments and no-shows is not billable. Evaluations and treatments are only billable for the length of time the therapist spends face-to-face with the patient, in 15 minute increments.
The evaluation is the first appointment following the initial referral by a physician. The evaluation normally lasts an hour, and is billable at a significantly higher rate than a treatment appointment. The higher rate allows for the fact that the therapist must take the time to prepare for the session in advance with some research about the patient and their medical condition, and afterward spend time filing a formal evaluation report which perfects the initial medical diagnosis inferred from the physician's referral slip and proposes a detailed medical intervention plan based on specific goals.

The evaluation report is usually prepared with the help of templatized software. It is nonetheless still time-consuming to prepare as it must specifically address the patient's needs as a unique individual. It is also a valuable document because it captures the therapist's entire professional training and expertise. The evaluation report is selectively shared as appropriate in consultations with the referring physician and other medical and payor personnel.

It may take an experienced therapist four or five man-hours to prepare for a new patient, host the evaluation, design an intervention plan, consult with others on the findings and recommendations, and complete the follow-up paperwork. In environments which only track therapist billable time as a productivity metrics, this substantial amount of work that is incidental to an initial patient evaluation work is never measured, and so neither tracked nor directly rewarded.

The treatment sessions are scheduled after the initial evaluation. Treatment sessions implement the medical intervention plan outlined in the evaluation report. The treatment sessions are billable at a lower rate than evaluation reports. As with evaluation sessions, only time spent face-to-face with a patient is billable. At the end of every
treatment session, the therapist must file a progress note. Payment for the follow up work is included in the rate charged for services, but not explicitly so. So the time spent on the progress note, however valuable and meaningful, is not directly billable.

These treatment progress notes are a shorter version of the evaluation report. Like the evaluation report, they capture the patient's SOAP (Subjective, Objective, Assessment, and Plan) elements. The subjective element (S) records how the patient feels, as expressed by what the patient says, asks or complains about, or reacts to treatment. The objective element (O) records the patient's progress towards the intervention plan goals in measurable terms. It also captures the therapist's observations and follow-up instructions to the patient and their caretaker. The assessment element (A) serves to assess the effectiveness of the treatment plan by naming factors impacting the patient's ability to attain goals. These include things like the patient's disposition, cooperation, and self-motivation. It also documents changes in the treatment plan, and the patient's prognosis. The plan element (P) maps the progression of the treatment over the initial evaluation plan. It lists changes in the frequency or number of anticipated treatment sessions, goal variations and adaptations, and the next steps in the patient's cycle of care.

The time and skill expended on the part of OTs and PTs with paperwork, case research, and internal follow up is considerable. However, in most every OT/PT shop, OTs and PTs are administratively measured and rewarded based entirely on a single control, their billable time for the week. In some medical practices, OTs and PTs are paid only for the hours they billed in a given week for evaluations and treatments. Others consider the OT and PTs to be employees, and control their productivity administratively.
by setting a billable work hour quota percentage. The quota is pro-rated as need to adjust for the number of hours the therapist is available for work, full-time or part-time. (This was the situation for the therapists in the case study that is part of this work.)

Important to the OT/PT patient scheduling context of this study is to note that there is no differentiation in the billable time administrative control between billable hours spent conducting evaluation sessions, and billable hours spent conducting treatment sessions. This despite the difference in the billable rates for each type of session, and the widely differing number of man-hours required in preparation and follow-up work. A solution to this problem is presented later in this study by the introduction of the workload concept.

2.1.6 Payors

Virtually all patient services rendered by the pediatric OT/PT department require a pre-authorization from a third-party payor at the state or federal level (Craig and O'Farrell, 2007; Pear, 2007). In most cases, the third-party payor is a private insurance company or a government agency (Craig and O'Farrell, 2007; Pear, 2007; SCHIP, n.d.). On occasion it is also a charity fund (Craig and O'Farrell, 2007). A significant number of states charge co-payments for physical and occupational therapy (Fox, Limb and McManus, 2003). Relatively few families bear the direct and full cost of OT/PT care for child patients with special needs (Peters, 2005).

The fact remains that on the aggregate, the total health care expenditure for special care children is historically more than three times greater than the average for
other children (Newacheck and McManus, 1988). For example, ADD may require a couple hundred dollars in care per month. More serious medical conditions such as spina bifida may call for monthly expenditures exceeding several thousands of dollars per month (Nyman and Ireys, 2004).

The third-payors for these services, largely private insurers and government wellness programs, have a natural tendency to try to contain these sizable costs. For example, in a study of a private insurer, special care children were only 12% of all enrolled children but accounted for almost 50% the total plan outlay costs (Nyman and Ireys, 2004). Their per member–per month expenses were also nearly four time greater than those of other children (Nyman and Ireys, 2004).

Because special care children often require recurring appointments over extended periods of time, their frequent need for third-party pre-authorization for services compounds the usual woes related to payment for medical services faced by the other populations served by these same third-party payors. The recurring, extended appointments quickly bump up against artificial authorization limits set by the payor on the number and frequency of services available to the patient. For example, the payor may arbitrarily limit the number of reimbursable OT/PT therapy sessions to only 3 or 6 per year for a given medical condition, regardless of the patient's individual medical needs. These payors ink the checks to their fortunes with the blood of the patients they abandon.

Although 95% of special care children have some type of insurance or wellness fund coverage, nearly one third are also underinsured, and so cannot meet all their medical needs (Kogan, Newacheck, Honberg, et al., 2005). Among the uninsured, 2 out
of 3 special care children with a disabling chronic condition report an unmet health need (Callahan and Cooper, 2005). Even if insured they also have higher levels of unmet need for medical services than other children, 5.3% against 1.6% (Davidoff, 2004). They are thus at least twice as likely to have unmet health care needs as other children (Peters, 2005).

Of particular interest in this study is that, because the majority of special care children do have health insurance (Kogan, Newacheck, Honberg, et al., 2005; Peters, 2005), the scheduling of OT/PT therapy sessions is actually complicated by back-office paperwork and layered workflows tied to pre-authorizations and qualified reimbursements (Callahan and Cooper, 2005; Callahan and Cooper, 2006). The third-party payors tend to seek to reduce their costs by expediencies such as delaying authorizations, narrowly limiting the frequency and scope of services they will reimburse, imposing burdensome documentation requirements, or denying coverage outright.

As demonstrated in this study, it is perfectly possible and reasonable to separate the pre-authorization for OT/PT services from the scheduling of OT/PT appointments. With documentation, payment issues for hosted sessions eventually resolve themselves. With time, medical issues for missed sessions only compound themselves.

2.1.7 Administrators

OT/PT administrators are charged with mediating and facilitating the many daily interaction events between the patients, their caretakers and caregivers, and the schedulers and payors described above. They function in a complex environment in
which they both steer and are accountable to multiple stakeholders. In OT/PT settings, administrators are generally called to balance and resolve competing interests and conflicting needs to an even greater extent than other medical practices. In larger OT/PT settings serving larger populations and multiple satellite locations, administrators are aided by coordinating supervisors. These supervisors play an important role in facilitating the cycle of care overseen by the managing administrator.

One of the responsibilities of administrators is to recruit, develop, and motivate highly skilled office and clinical personnel teams in a way that will best serve the needs of the patients and advances the institutional mission of patient care. They are also ultimately accountable to every patient and to the community at large. They must also see to the effective and efficient utilization of all resources, as indicated by detailed and demanding controls tied to institutional productivity metrics, legislated mandates, review boards, and quality of care standards. In such a complex environment, multiple administrative controls are needed. Single dimension proxy controls such as metering billable time are both inadequate and insufficient (O'Keefe, 1985; Jones and Russell, 1990). To help provide more meaningful and effective controls, the automation proposed in this study generates several reports which do not require any data input or manipulation. Examples are reports which show patient referral, evaluation and treatment wait times, percentage of patients served at the caretaker's preferred service location, patient and therapist appointment histories, therapist workload distribution, medical discipline coverage by therapist and location, and therapist utilization by location.
2.2 System Dynamics And Action Research

This study combines Action Research with System Dynamics. The combined approach invites the abstraction of isolated facts and observations into systems-oriented generalizations, encourages measurement and so quickly becomes quantitative, and is theory building in a way that grows in predictive power. Both approaches have a long history in the literature (Shell and Martin, 1988). Their power resides in the fact that they encourage a disciplined experimentation with the familiar, and so can quickly become a powerful way to look and think about the system of interest in a new way.

Action Research is a people-oriented form of industrial Kaizen (Lewin, 1946; Argyris, 1970). Action Research is an interventional technique for incremental system improvement. In Action Research, a system in which people play an important role is studied, and then re-arranged in a way that better suits all stakeholders. The methodology gets its name from the fact that the system observers are also actors in it. Insight from "what if" thinking is used to plan an action. Fact-finding and observation of the result of the action is then used to gain a better understanding of the most appropriate next action.

System Dynamics is a time-oriented form of Control Theory (Forrester, 1958; Forrester, 1993; Franklin, 2002). Like Action Research, System Dynamics is also an interventional technique for incremental system improvement. Its transformational power arises from its ability to convert isolated and disjointed micronetic behaviors into coordinated and optimizing macronetic ones. In System Dynamics, a system with well-defined input and output processes is identified and then energized with a deliberate injection of some of the system's output as its own input. This injection constitutes the
"feedback." The idea is to throttle the nature and level of the feedback in a simulation so as to tune the system by observation, and so also learn to direct, stabilize, and optimize its state over time (Ackoff, 1999; Ackoff and Addison, 2006).

2.3 Separation Of Duties

Separation of Duties is one of the key concepts of internal control (Root, 2001). Separation of Duties seeks to disaggregate operational roles so that no single party controls more than one aspect of a given workview (Thomas, Seiferth and Kelley, 2004). The four aspects that must be considered are authorization, tracking, custody, and reconciliation (Root, 2001).

2.4 Queue Terminology

A queue is simply a list of items waiting to be processed, and a schedule is a plan for the processing of the items in one or more queues. In queuing theory, the unit using the queue, human or otherwise, is a customer, and the unit providing service to the queue is a server (Bhat and Basawa, 1992). Typically there are multiple customers, and one or more queues and servers, in series or in parallel.

The term discipline describes the set of rules followed by the queue when processing customers. A discipline may be greedy or optimizing. A greedy variant executes with what it has at hand and moves on. An optimizing variant attempts to swap or jiggle execution elements in some systematic fashion in an effort to improve the
A *multi-tasking* discipline processes unrelated tasks in an interrupt-driven matter. A *multi-processing* discipline apportions related tasks to separate processes, and then coordinates their re-assembly. Common disciplines are deterministic (D), random service (RS), and chronologically, either on a first-come, first-served- (FCFS) or last come, last-served- (LCLS) basis (Bhat and Basawa, 1992).

There are many discipline variants. Some simply reflect a best-effort policy. Others may seek to meet a guaranteed quality of service metric by implementing some degree of prioritization or some type of polling. *Prioritization* may consider the customer classification, a momentarily favorable channel, the shortest anticipated processing time, or the highest anticipated throughput. *Polling*, or baton-passing, may be round-robin, in which each customer is given in turn an equal opportunity, or it may involve some form of fair queuing or statistical multiplexing.

The *access process* consists of a discipline and the rate of customer arrivals. Similarly, the *service process* consists of a discipline and the rate of customer departures. The *departure process* is the combination of the access and service processes. Whenever the customer access rate exceeds the server processing rate, a queue of customers results. The number of customers in this queue, the *length of queue*, is also referred to as the *queue backlog*. In certain applications, such as streaming video, the queue backlog acts as a beneficial *buffer* which masks erratic packet arrival rates. In other applications, such as patient scheduling, the queue is a detriment because it introduces a *wait time* which is proportional in some fashion to the number of earlier customer arrivals already in the queue. The queue backlog will be cleared only when, at least momentarily, the *server*
processing rate increases, the customer access rate decreases, or some customers abandon the queue.

The waiting time is time a new customer arrival has to wait before its service begins. The queue length and the waiting time are stochastic processes. A busy cycle consists of a busy period and an idle period. The busy period is the duration of time the server is continuously busy. It is a random variable. When the busy period ends, the idle period begins. If a busy cycle has no idle period, congestion may ensue. When the server is continuously busy, the departure process coincides with the service process. But when idle periods kicks in, the departure process stops as well. Distribution characteristics of the stochastic processes and random variables are needed to understand their behavior. Because time is a factor, the analysis has to make a distinction between the time dependent, or transient behavior, and the long-term or limiting behavior.

Customer arrival patterns are described as modes of input. When customers arrive at rates driven by external random factors, as is the case in this study for patient referrals from physicians, the input process assumes a statistical profile described by the number arriving during a given time window, or by the interval of time between successive arrivals. A common arrival pattern is the Poisson distribution. Poisson-distributed arrivals are memoryless, an the difference in arrival times between subsequent customers has an exponential sampling distribution (Evans and Olson, 2003).

When the arriving customer has discretion over which queue to join, there is jockeying, and when the customer has discretion to abandon the queue, there is reneging. Customers can also balk, that is, not enter the queue if they see the queue length is too long, and be denied service if the queue is already full. These behaviors occur daily in
retail grocery store checkout lanes and airline counters. They are also important for patient scheduling applications when the customer has the option to seek treatment at competing medical facilities.

The notation "mode of input / service / number of servers" is a handy queue shorthand sometimes seen in the literature (Bhat and Basawa, 1992). As examples, with M for Poisson or exponential, D for deterministic, E_k for the Erlang distribution with scale parameter k, and G for general, consider: M/G/1, E_k/M/1, and M/D/n.

A collection of random variable samples indexed by an ordinal parameter such as time is known as a stochastic process. In such a process, the behavior of the system is determined by the probabilistic equations that drive time-dependent random variables. The queues of interest to this study are stochastic in nature. For example, the number of customers recorded to be in queue at state sample time s when indexed with the parameter time t is a stochastic process.

More formally, let Q(t) be the number of customers in the queue at time t. Let A(t) be the number of arrivals, and D(t) the number of departures during the interval (0, t). Then

$$Q(t) = A(t) - D(t)$$

Clearly, the stochastic process Q(t) is dependent on both A(t) and D(t). Both A(t) and D(t) in turn are themselves stochastic processes. So, to understand and eventually optimize the behavior of Q(t), the individual properties and the inter-dependence characteristics of A(t) and D(t) must be understood in terms of observable and
measurable parameters. An adequate parameterization of a queue is thus important to the understanding of its properties and behavior.

To the extent that the queue behavior $Q(t)$ is to be optimized, the observable parameters used to tune $A(t)$ and $D(t)$ must be defined in terms of experimental parameters which are configurable, well-behaved, and well-defined. Configurable parameters are those that can be changed by the application of administrative controls. For example, $A(t)$ could be configured by specifying in an operational policy that the precedence order of patient booking is aged patient over a newly arrived one (FCFS), or newly arrived over aged (LCFS). Well-behaved parameters have a known impact, as expressed by the sensitivity of the observable behavior of $A(t)$ and $D(t)$ to changes in their values. Well-defined means that the independent characteristics of the parameters are sufficiently well understood, including any interdependency relationship with other configurable parameters.

When customers and servers are balanced by tuning the stochastic processes $A(t)$ and $D(t)$, a queue system in operation attains a steady state or statistical equilibrium. At steady state, a random snapshot fairly captures one sample state $j$ having a probability $p_j$ from within the probability distribution of possible queue states. If the process is well behaved, it will reach a statistical equilibrium that is independent of time and of the initial state of the system. Once at equilibrium, the expected number of customers serviced during a time interval is the same as the number of customers who arrived during that same interval.

More formally, let $t$ be the transpired time, $Q(t)$ be the number of customers in the queue at time $t$, $P$ be the process $\{Q(t), t \geq 0\}$, $i$ its initial state, and $s$ the state sample
time, $s < t$. By defining the transition probability $P_{ij}$ of the process from state $i$ to $j$ as

$$P_{ij}(s, t) = P(Q(t) = j | Q(s) = i)$$  \hspace{1cm} (2)

then at statistical equilibrium we can write:

$$p_j = \lim_{t \to \infty} P_{ij}(s, t)$$  \hspace{1cm} (3)

Under time-insensitive statistical equilibrium, balancing the state equations is simple and the limiting distribution of the queue size associated with a given state $s$ when $P$ is sampled can be obtained by resort to ordinary matrix methods or even simple recursion. For time dependent systems, more advanced mathematical techniques become necessary, including Laplace transforms and generating functions for the differential equations governing the underlying queue processes (Bhat and Basawa, 1992).

2.5 Queue Literature

This section looks at the literature on queuing theory and the medical appointment scheduling algorithms that are relevant to this study.

Bhat has published a comprehensive review of queuing theory and models (Bhat and Basawa, 1992). He ascribes the first papers on formal queuing theory to telephony work by Johannsen in 1907 and Erlanger in 1909. The first queuing optimization work is
ascribed to a paper on telephony traffic congestion written by Erlang in 1924 (Bhat and Basawa, 1992). The work was however first published only in 1948 in a Festschrift dedicated to A. K. Erlang (Brockmeyer, Halstrøm and Jensen, 1948).

Erlang's papers are celebrated because they helped introduce important concepts to queuing theory: (a) the notion of statistical equilibrium, joint probability distributions, and balance of state equations; (b) Markovian stochastic and Chapman-Kolmogorov transition densities; and (c) Poisson arrivals and exponentially-distributed inter-arrival times (Bhat and Basawa, 1992; Evans and Olson, 2003). These concepts have been perfected, extended, and refined over the last 40 years.

The early telephony-oriented work on queues soon branched into transportation, manufacturing, and warehouse distribution logistics, among other fields. Eventually, especially as IBM began to introduce transistorized mainframes to hospitals beginning early in the 1960's, also to patient appointment systems. By 1981 a broad-based survey off some 200 initial implementation attempts of computer simulations in healthcare had appeared (Wilson, 1981).

The early work of the Bailey and Welch team (Bailey, 1952; Welch and Bailey, 1952; Bailey, 1954; Bailey 1955; Welch, 1964) is reported to be the first to apply formal queuing theory to outpatient patient appointment systems in hospitals (Wijewickrama and Takakuwa, 2005). Bailey and Welch constructed various graphs and tables as forms of administrative control and measures of effectiveness. The 1952-1964 body of work of Bailey and Welch is significant because it was some of the first focused on reducing the waiting time of the patient, as opposed to minimizing physician idle time:
"[We] compared the waiting time of patients and consultants in a number of orthopedic clinics [...] 75 percent of the patient's time was spent in waiting of one kind or another but only 15 percent of the doctor's time. Of that 15 percent, 13 percent was spent of waiting for X-rays and only 2 percent of his time in waiting for the patients. It is difficult to do otherwise than conclude that the appointment systems are organized more in the doctor's interest than in that of the patients." (Welch, 1964)

The early work of Bailey (1952) established that the best scheduling policy was to place two patients at the start of the session and then stagger patient appointments evenly at 5 minute intervals, the observed average service time. Their simple rule "remained one of the best over the past fifty years" (Wijewickrama and Takakuwa, 2005).

Most of the theoretical patient appointment systems since Bailey and Welch has sought to combine ad hoc individual appointment setting with some form of block-based appointment setting. In block-based appointment, more than one patient is scheduled for the same timeslot, sometimes in a staggered manner. Experimentation with this initial combination soon led to variants like single-block/individual, single-block/multiple-block, multiple-block, and variable-sized/multiple-block appointment setting strategies (Bhat and Basawa, 1992; Wijewickrama and Takakuwa, 2005).

Like Bailey and Welch, Jansson in 1966 also applied queue theory to appointment systems (Jansson, 1966). In similar to Bailey and Welch, the cost of the system in Jansson's work was defined as a linear sum of the cost of keeping customers waiting for service and the cost of having the service station idle (Jansson, 1966).

Beginning in about 1969, and into the early 1980's, an increasing number of simulations of patient appointment systems in outpatient medical settings appeared (Katz,
1969; Wilson, 1981). But according to a 1981 review, only about 16 of the observations from simulations described in the 200-odd papers surveyed found any implementation in practice (Wilson, 1981). The conclusion was that the key elements needed to successfully map a real-world patient appointment scheduling application in medical settings into a simulation, and vice-versa, were not yet sufficiently well understood. For approximately 10 years afterward, the literature returned to more qualitative studies (O'Keefe, 1985; Brahimi and Worthington, 1991).

By the early 1990's it was recognized that multiple success measures and more sophisticated rules based on competing or conflicting scheduling outcome preferences were needed to formulate a meaningful simulation (Jones and Russell, 1990; Bhat and Basawa, 1992; Ho and Lau, 1992). Afterward, and especially as computers became easier to program, and more powerful and widely available in the 1990's, the literature returned to outpatient scheduling simulations and modeling. This time there was a greater emphasis on enable health care administrators to run different scenarios in software simulations in a way that would help them understand how to relieve outpatient patient scheduling congestion and dissatisfaction in practical terms (Aharonson-Daniel, Paul, and Hedley, 1996). It was also about this time, in 1993, that the value of computerization to the workflow of OT/PT scheduling was recognized (Edmiston and Rapps, 1993):

"The patient treatment schedule for the Occupational Therapy Department [...] is currently displayed on a large magnetic board. [...] Each day the program specialists of each therapy team must reschedule the patients who are seeing therapists who are off. The rescheduling is now done by a manual trial and error system. This process could more quickly and efficiently be completed by a computer system."
By the early 2000's, the greater understanding of the need to be inclusive of multiple scheduling outcome values and perspectives resulted in an effort to show how computers could be used in the daily medical practice of occupational therapists (Jette, Bacon, Batty, et al., 2003). Particular emphasis during this period was placed on identifying the values and experiences patients seeking therapy had in common which acted as barriers to honoring their scheduled appointments (Hanson, Neuman, and Voris, 2003; Cunningham and Hadley, 2004; Mayer, Skinner, and Slifkin, 2004; Randolph, Murray, Swanson, et al., 2004; Seid, Sobo, Gelhard, et al., 2004).

By the mid-2000's, outpatient scheduling simulations had re-appeared (Guo, Wagner and West, 2003; Giachetti, Centeno, Centeno, et al., 2005; Wijewickrama and Takakuwa, 2005). This time the work was on a stronger theoretical foundation, after the pattern of the lessons learned from manufacturing productivity improvement studies (Jones and Russell, 1990; Huang, Dismukes, Shi, et al., 2002; Sun, Ding, Xiong, et al., 2004). The work also availed itself of the widespread availability of powerful and inexpensive computers and sophisticated plug-and-play modeling software packages (Guo, Wagner and West, 2003; Giachetti, Centeno, Centeno, et al., 2005; Wijewickrama Takakuwa, 2005).

In 2003, only ten years after Edmiston's wistful magnetic board observation, Lesins reports on the implementation of a commercially available software specialized for the scheduling of outpatient appointments at a medical facility dedicated to OT/PT and speech rehab therapy (Lesins, 2003). The software had been implemented address the internal finding that "patient scheduling was identified as an obstacle to both
customer service and departmental workflow in outpatient services” (Lesins, 2003). The issues raised all ring familiar to today’s OT/PT practitioners:

- To schedule or change appointments took several calls to the patient;
- It took 15 minutes to schedule an appointment;
- There were many scheduling errors, frequent bottlenecks at the front desk and long wait times for patients;
- The practice was growing rapidly, but the three full-time schedulers were able to schedule no more than 300 appointments a week;
- New personnel required a full week of training to learn the scheduling;
- Therapists spent a considerable part of their day scheduling their own follow-up appointments for their patients; and
- There were few reports for administrative tasks and performance tracking.

The improvements to the OT/PT practice after implementation of the scheduling software were dramatic (Lesins, 2003). However, the most significant benefits noted benefited the therapists, the schedulers, the payors, and the administration:

- "Now our [therapists] are no longer spending 15 minutes between each appointment to schedule follow-ups for their [own] patients. This has freed up time for them to complete their patient documentation and move on to other patients;"
- "After just three months, the time to schedule an appointment dropped from 15 minutes to three minutes;"
- "[We] gained the ability to track how many visits a patient has authorized and how many remaining visits they had. Before, we
could only do this by manually locating a patient's chart and looking up the information. This allows us to efficiently ensure that a patient has visits available before we even schedule another appointment."

- "The increased efficiency we have experienced has allowed us to add only one additional scheduling position while we have nearly tripled the number of appointments scheduled. The user-friendliness of the system also has enabled us to cut training time for new employees from one week to two or three hours. [...] more than 30 [new] scheduling-specific reports [...] allowed us to manage the department more efficiently, and, as an added benefit, the IT department has not had to create any custom reports."

The benefits to the patient mentioned included the generation of summoning letters reminding them of their "duty" to show up for their appointments, and the gleeful observation that patients spent less total time on-site (Lesins, 2003).

2.6 Existing Approaches To Patient Scheduling

Several different approaches to the scheduling of patients have been attempted over the years. Many variations are in use in daily practice. This section briefly considers some of the approaches more closely appropriate to OT/PT patient populations.

It is important to note at the outset that OT/PT appointments for special chare children have some distinctive characteristics which on the whole require some specialization of traditional approaches to patient scheduling.

The first one of these is that, as children, they are completely dependent on their caretakers. Their caretakers must negotiate their appointment with the hospital on their
behalf, and provide their transportation. The quality of fit to the caretaker's appointment preferences in terms of location, weekday, and daytime are extremely important.

A second consideration is that the medical condition of special care children is generally not acute, but chronic. In simplistic terms, they are not in immediate pain, and their condition is long term, and so expensive to treat (Cohn, 2007). This means that it does not usually matter greatly whether they are seen immediately or in a week's time. It is only important that they be seen before the condition for which they are seeking OT/PT therapy establishes itself to the point where the OT/PT therapy intervention is unproductive.

A third consideration is that appointments are mediated, do not have a deadline, have long service cycles, and face authorization barriers. The patient treatment plan will likely require multiple sittings, and be spread out over a cycle of care that may extend over several weeks or months, and sometimes longer. At the same time, the likelihood that the treatment series anticipated by the plan will need pre-authorization for services from a third-party payor is also generally greater because special care children are more likely to be insured than a patient at large. For example, a scheduler may have to delay an appointment for two weeks to allow for the fact that there is an arbitrary OT/PT therapy limit of 6 re-imbursable sessions per calendar quarter (Sonnenberg and Crain, 2005).

A fourth issue is that there is an unwritten expectation that the scheduling of OT/PT patients will conform to one or more of the following 10 basic forms of outpatient scheduling in medical settings (Bhat and Basawa, 1992; O'Hare and Corlett, 2004; Sun, Ding, Xiong, et al., 2004; Giachetti, Centeno, Centeno, et al., 2005; Wijewickrama and
Takakuwa, 2005). The problem with this expectation is that they are all practice-facing. None of these 10 basic forms of outpatient scheduling are patient-facing, at least not in the specialized form needed to support the scheduling needs of OT/PT appointments aimed at special needs child patients.

1. **Walk-In Scheduling.** Here, the patient's caretaker simply shows up, patient in tow, without a formal appointment, and fills a so-called open appointment slot. This is the scheduling often used in emergency room and community clinic settings. In practice, in the context of OT/PT therapy, the caretaker will have inquired in advance about the need for a physician referral, the general availability of services and service locations, and discussed payment options, including whether there is a need for third-party pre-authorization. On arrival, the patient sees whatever therapist is on duty and momentarily idle. On departure, the caretaker inquires about the timetable for the next appointment, but leaves without a formal appointment.

2. **Ad Hoc Scheduling.** The most common scheduling approach. These are ordinary fixed appointments. Upon receipt and processing of a referral, the scheduler and the caretaker negotiate. The patient is assigned a suitable evaluation appointment with the next therapist in some patient-load balancing rotation. Upon completion of the evaluation, the therapist assigns the patient a ribbon or coupon of treatment appointments extending several weeks into the future.
3. **Vacation Scheduling.** This scheduling approach is pre-occupied with exception handling. It gets its name from the fact that an existing appointment is vacated, in the sense of being pre-empted. Schedulers adjust the appointment schedules of both the patients and the therapists as needed to allow for holidays and therapist vacations, and patient re-schedule requests following no-shows and cancellations due last minute conflicts. The magnetic board case described below in the literature section is an example of vacation scheduling.

4. **Naive Overbooking.** Naive overbooking seeks to compensate for high no-show rates and cancellations commonly observed in OT/PT practices, and many other outpatient-based medical practices, on the order of 15-35% (Peters, 2005). It deliberately overbooks patients sharing the same medical condition characteristics at the same rate as the average no-show rate. Staggered patient arrivals may also be used to smooth out the impact of otherwise clumped arrivals on weary therapists.

5. **Block Scheduling.** Block scheduling schedules groups or blocks of patients to arrive at the same appointment time. The patients then fan out to their individual appointments as they arrive, and as a therapist becomes available. The approach tries to add more structure to naive overbooking by setting aside blocks of time for specific purposes, for example entire weekdays or half-days are set aside for new patient evaluations, and parts of other days are dedicated consultation and report-writing, or ordinary treatment sessions.
6. Open Access Scheduling. This is a form of scheduling in which the clinic administrators set an upper limit cutoff for the maximum number of fixed appointments a scheduler may book to service existing appointments, and a minimum percentage of open appointments to be assigned on short notice to new patients. The determined by trial and error based on a combination of observation and experience. The approach thus has some built-in learning intelligence. Variations are sometimes called Advanced Access in the literature.

7. Discretionary Scheduling. Here factors which are external to the appointment setting process itself are overlaid with the appointment scheduling effort. The approach gets its name from the fact that appointment decisions are made based on rules applied at the discretion of an authority. The exercise of the discretion may extend or curtail the appointment options available to the scheduler and the patient. For example, a therapist may decide that a patient would benefit from weekly therapy sessions instead of semi-monthly. A payor may impose a duty cycle of no more than 6 OT/PT appointments per calendar year. Or the administration may require a minimum or average number of hours billed by all therapist on duty for a given week exceed a threshold value before another therapist is brought on duty at a given satellite location.

8. Channelized Scheduling. Here, the patient appointment is differentiated by type, as a referral, an evaluation, an initial treatment session, or a recurring treatment session, before being handed to a scheduler for action. The effect of the approach is to assign specialized roles to individual schedulers. The intent is improve the scheduling
efficiency by removing distractions. The approach does not attempt to coordinate the efforts of the individual schedulers.

9. Retrial Queuing. Retrial queuing defines a special category of appointment, an appointment for a patient who was denied an appointment in a previous appointment setting cycle. The patient may have been turned down because of capacity issues, but also for having failed to obtain some pre-requisites, for example, a pre-authorization for services from a third-party payor. Having been skipped in the past, such patients are then given special and usually preferential consideration the next appointment setting cycle. For example, by incrementing a retrial queue flag after every failed retry attempt, they could be placed progressively nearer the beginning of their channel queue. Like channelized queuing, retrial queuing has a built-in optimization intelligence.

10. Dispatch Scheduling. In this approach, the schedulers review their success in an earlier scheduling cycle, and then adjust their scheduling efforts to improve on the least successful outcomes. The criteria for success is usually based on some percentage of unscheduled appointments within a given category that were successfully booked. The approach gets its name from the iterative nature of the messages, the dispatches, received from the earlier appointment setting efforts. The dispatches act as learning devices that aid in the self-optimization. Dispatch scheduling is an example of a goal-seeking scheduling strategy.
Each of the approaches above, when implemented, measures its effectiveness and efficiency with controls based on observable metrics. These controls and metrics usually try to gauge how well the scheduling process has been able to meet the scheduling demand with meaningful patient bookings. This study adds a new basic construct to this list of 10 basic ones, *rollover polling*, which is capable of automating the scheduling of an entire OT/PT patient population at a time.

### 2.7 Conclusions From The Literature

1. **There Is A Needy Landscape.** The need profiles of OT/PT child patients have been well categorized. Their demographics document a large patient population with early and lifetime needs, and great societal impact, because their needs on average greatly exceed those of the population at large. These escalated needs are expressed in many ways: the great degree of appointment mediation by caretakers, the longer term intervention by caregivers, the greater modulation of services by payors, the greater degree of conflict filtering that must be exercised by the schedulers, and the greater coordinating overhead faced by the facility administrators.

2. **The Early Patient-Centered Vision Has Been Lost.** The basic appointment needs of OT/PT patients can be served by an evaluation session that is then followed by therapy in the way of repeated treatment appointments. This basic cycle can be met by differentiating therapists by OT or PT skill set and subspecialty, and following a care plan. However, as the cycle of care has grown in complexity by theoretical research and
applied practice, the access to care by the special care child patient population has become more layered by stakeholders and software, and so also increasingly more filtered and modulated. In the process, the barriers to access to care have escalated, and the early patient centered vision of Bailey and Welch (Bailey, 1952; Welch, 1964) has been lost. As was the case 50 years ago, today's vision remains centered on the needs of the patient's caretakers and therapists, the hospital administrators, and the third-party payors (Lesins, 2003; Peters, 2005; Craig and O'Farrell, 2007; Mason, 2007; Pear 2007).

3. The Next Steps Call For Scale By Automation And Optimization. From a process evolution hierarchy perspective, the appointment scheduling of OT/PT child patients is still at the artisan stage. The emphasis is still on single item appointment production, even though the appointment needs of OT/PT child patients are well-defined, and long term and recurring in nature. To improve scale and sustainability at large OT/PT practices serving large populations out of multiple satellite locations, there is a need to eliminate single-stitch appointment setting, and instead automate the scheduling of the entire OT/PT patient population as a whole.

4. A New Type Of Population-Based Appointment Scheduling Is Needed. To support the automation of population-level scheduling, there is a need for a new approach to OT/PT scheduling. The current state-of-the-art software allows keyboard and mouse input on the part of schedulers, therapists, and administrators. It then stores, packages, and tracks this input in a way that allows state lookups, that is, insight into available slots and booked appointments. The software typically allows the selection of a scheduling
profile appropriate to the practice, and even applies built-in safeguards to avoid overbooking locations, equipment and physician. It also often offers interconnections via billing codes to templatized report writers, and applications related to pre-authorization, chart administration, billing, and payroll. It also offers specialized stakeholder views and reports designed to appeal to patient, caretaker, caregiver, and payors. It even allows for aggregation and analysis in reports. But it is anthropocentric and as such limited for our purposes. It only captures and applies rules to individually observed actions and behaviors. It does not learn from them. The next generation OT/PT scheduling system must abstract this piece-meal, human-level input in a way that serves the needs of a goal-directed system that can learn from the recurring nature of OT/PT appointment schedules, and use this learning to sharpen its decision-making intelligence.

5. The Pre-Requisites For Advancement Exist. Queue theory and scheduling theory are well established and able to support the study. Computers that are easy to program are widely available. Statistical simulations are valued as a means to study scenarios, validate assumptions and understand controls quantitatively. They help make intelligent predictions and informed decisions aimed at driving the scheduling system's behavior towards desirable goals.
Chapter 3 - Theoretical Model Development

This section describes a new system for the scheduling of OT and PT therapists that is patient-centered. The approach is developed here in the context of an OT/PT therapy clinic at large hospital and multiple satellite service locations. It is however also applicable to any medical environment that schedules patients for recurring appointments over extended periods of time, such as diabetes and cancer treatment centers, assisted living and home care environments. Of particular note is that the approach preserves the need for flexibility on the part of therapists and patients to reschedule, shorten, and extend anticipated appointments as needed.

3.1 Automation Framework

The conceptual model for the scheduling system developed in this chapter seeks to make it easy to automate and optimize the scheduling of the patient population in a way that will:

- More closely and effectively serve the patient's medical by means of easier scheduling and greater appointment setting flexibility;
- Schedule more patients at the facility and during the weekday time slots preferred by the patient's parents and care-givers;
• Shorten the time between the receipt of a patient referral, and the scheduling of the patient's evaluation and treatment sessions;

• Facilitate the matching of the patient's primary diagnosis to a therapist with a suitable specialization;

• Maximize billable therapist patient time by freeing therapists from scheduling responsibilities, and so improving therapist job satisfaction and retention by reducing distractions and frustrations;

• Enable greater access to medical care, as measured by increased conversion rates of physician referrals to billable evaluations, and of hosted evaluations to billable treatment sessions;

• Reduce patient abandonment rates, as measured by fewer failures to evaluate and treat a patient, and fewer appointment cancellations and no-shows due to frustration with scheduling bottlenecks.

• Fairly distribute the patient case load into a more predictable and balanced weekly therapist workload of appointment hosting and report processing;

• More rationally predict and administer the number, distribution and utilization of therapists assignments needed to service multiple therapy locations;

• Enhance the ability of the hospital administration to monitor and control the productivity and well-being of the therapists and facilities they supervise, as well as the quality of medical care and level of patient and caretaker satisfaction with the services provided.
3.1.1 Intelligent Referral Processing

In the absence of full automation, an automated patient scheduling system must support the referral specialist's role in a way that is intelligent. The referral processing in an automated scheduling system must be intelligent enough to learn from previous OT/PT assignment determinations, and then make recommendations based on its earlier learning when it encounters a similar OT/PT patient assignment case in the future.

To facilitate the assignment of an OT or PT specialist, the scheduling system must learn the referral specialist's past decisions by recording them in a database, and then make recommendations from this database when presented with similar cases in the future. So a recommender is one of the first elements which must be included in an automated OT/PT patient scheduler. One such recommender is presented in Chapter 5.

3.1.2 Automated Evaluation And Treatment Session Processing

In an automated scheduling system, after a referral has been processed by the referral specialist, it must be queued for the scheduling of an initial patient evaluation session hosted by an OT or PT, and subsequently most likely queued for a series of treatment sessions. Because the evaluation session and the treatment sessions have different reporting requirements and billing rates, an automated scheduler must differentiate evaluations from treatment sessions.
After the patient evaluation session this OT or PT will create a treatment plan for the patient. Although in rare cases the OT/PT may decide no therapy is warranted, in most cases the evaluation will call for the OT/PT to develop a treatment plan for the patient which will typically require multiple follow up treatment sessions. The frequency and duration of these treatment sessions can and does vary depending on the patient's individual medical needs, but in an OT/PT setting, in most cases the treatment sessions are held weekly or every other week, begin at the top of the hour, and lasts for one hour or less.

At the end of every treatment session, the OT/PT may decide to modify, discontinue or extend the patient's care plan. So an automated scheduling system must support the scheduling of both the initial patient evaluation, and then act on the outcome of every treatment session. The outcome could call for another session. To ensure continuity of care, the automated scheduler must "roll" this appointment into another one with the same therapist, and at the same location, weekday, and time as the immediately preceding one. The roll mandated by continuity of care considerations is the basis for the automated rollover-polling scheduling strategy introduced by this study.

3.1.3 Automated Exception Handling

The automated scheduler must be able to handle the not-to-infrequent eventuality in an OT/PT recurring outpatient appointment setting that a scheduled appointment did not take place because the caretaker canceled, possibly at the last minute, or the patient was a "no-show." It must also handle re-schedules because of therapist days off and
holidays in an automated fashion. In an OT/PT outpatient setting, this secondary process takes the form of an out-of-loop letter writing and phone call effort directed at the patient and the patient's care takers which is aimed at encouraging the patient to honor their scheduled appointments. An automated scheduler must flag no-show and cancellation appointments as not billable, and also flag the appointment as having been missed. Depending on house policy, the automated scheduler must also drop further attempts at scheduling the patient until after a secondary process has taken place. In most OT/PT practices, the therapist who had been scheduled to host the missed appointment is also not given credit towards their billable work quota for the week. An automated scheduler must thus also track these missed appointments in a way that will provide a meaningful billable therapist utilization reporting function.

3.1.4 Automated Caretaker Processing

In an OT/PT therapy environment geared to children, both the evaluations and treatment sessions booked by an automated scheduling system are always mediated, and so constrained by the caretaker appointment preferences. The sessions booked must meet the week, weekday, and location preferences of the patient's caretakers. It follows that there must be a means for the caretakers to document their appointment preferences, and so capture them into a database. The automated scheduler can then abide by these pre-existing preference information, and any subsequent changes initiated by the caretaker, when scheduling the patient for OT/PT evaluation and treatment sessions.
3.1.5 Automated Therapist Processing

An automated caregiver processing system must take into account both the skillset and the work capacity of the therapist assigned to the OT/PT patient.

The patient's caregivers have specialized medical skills. They are licensed as either an OT or PT specialist (and almost never both). Like the patient's caretakers, the patient's caregivers also have personal preferences. Their preferences are expressed as sub-specializations within their OT or PT designation they tend to favor exercising over others. Although licensed to serve the full spectrum of conditions within their profession, these practice preferences may have been acquired either by personal preference, or are a natural part of their career development. They may also reflect their level prior professional experience acquired within more narrowly specialized practices, or the observations of their mentors and supervisors. An automated scheduler must differentiate between caregivers with OT and PT designations, and also respect their assigned sub-specialty preferences.

The therapists must apportion their work hours for the week between face-to-face appointments with patients, reporting activities related to these appointments, and administrative duties such as physician contact and case research. Not all of these activities are billable. As a unit of work they do however constrain the number of appointment slot options that are available to a new or existing patient.
3.1.6 Automated Administrative Reporting

The metering of a patient's care, a caretaker's satisfaction, the caregiver's effectiveness, and thus how well OT/PT facility is functioning within its mission and stated goals, is a complex proposition, because all of the elements are to some degree or another inter-related. For example, administrative controls aimed at measuring a caregiver's effectiveness must take into account several factors. Some of these are the outcomes of the therapist's intervention plan, the patient's progress, and, in an OT/PT practice geared toward children, also the caretaker's satisfaction with their services. As another example, the caretaker's level of satisfaction with the OT/PT facilities services is tied to their sense of their child's progress as much as to their perception of convenient access to a satellite care location near their home or work. The administrator may not however be able to make enough caregivers available at this convenient location due because they would be based at a location that is otherwise under-utilized.

As an element within this complex evaluation, an automated OT/PT appointment scheduler must track which appointment slots have been booked for which patient, and for what purpose. The purpose may be of three types: an initial evaluation, the initiation of a treatment series, or a follow-up treatment session. Separate, more specialized software is needed to document what took place during these different types of sessions. What is important to note here is only that, on the surface, beyond scheduling, the automated scheduler need only be able to report on the number of sessions the caregivers have hosted with any one patient at a given location, and how busy the caregiver was during the week with face-to-face appointment sessions with patients. In reality, any
such reporting will have factored in, directly or indirectly, the entire patient cycle of care
workflow.

3.1.7 Automated Multi-Point Scheduling

The automated scheduler must perform a multi-point match between the patient's
medical needs, the caretaker's appointment preferences, the caregiver's skills and work
hour limits, and the administrator's goals within the mission of their unit. More formally,
in short-hand notation, the automated scheduler must cross-match the following:

- Patient(MedicalNeeds)
- Caretaker(Week, Weekday, Time, Location)
- Caregiver(OT/PT Designation, Skillset, WorkLimits)
- Payor(Accountability)
- Administrator(AccessToCare, TherapistProductivity, LocationUtilization)

All of the above elements have been discussed, and can be captured and processed
by an automated OT/PT scheduler. There are two elements however which warrant
further discussion, the caregiver's work limits, and the administrator's access to care
considerations.
3.2 Caregiver Work Limits

In an OT/PT practice, the caregivers may be independent contractors or employees, and work part-time or full time. Like all employees and contractors, they occasionally take days off because of vacations, illnesses, or the need to tend to others or run personal errands. As discussed earlier, they also have reporting, physician contact, case research, and administrative responsibilities which extend beyond their face-to-face time with a patient. Within the context of OT/PT facilities, these other responsibilities are however not directly billable. They are captured only indirectly in the fee charged for OT/PT services. For example, the fee charged for an OT/PT evaluation is higher than the fee charged for a treatment session. In addition, there is often a significant variation in the rates paid by different payors for the same services. Different re-imbursement programs may have contracted for, or be willing to pay, higher or lower rates than other payors.

3.3 Billable Time (B)

To measure how well an OT/PT facility is serving its mission of care, an OT/PT facility cannot rely simply on an income statement. It must use other measures of productivity and effectiveness as proxies. OT/PT facilities commonly use a percentage expressed as the fraction B of the number of weekly billable hours booked by their therapists as one such proxy. Let this fraction be defined in terms of the hours billed for evaluation and treatment sessions, as follows:
Here, the number of hours billed is based on the number of hours actually spent face-to-face in the presence of the patient. These hours can be approximated from the average duration of the individual appointments:

\[ H_e = \sum_{i=0}^{n_e} h_{e,i} \approx n_e \cdot \bar{h}_e \]  

(5)

\[ H_t = \sum_{j=0}^{n_t} h_{t,j} \approx n_t \cdot \bar{h}_t \]  

(6)

\[ H_p = \sum_{k=0}^{n_p} h_{p,k} \approx n_p \cdot \bar{h}_p \]  

(7)

and so

\[ B = \frac{n_e \cdot \bar{h}_e + n_t \cdot \bar{h}_t}{n_p \cdot \bar{h}_p} \]  

(8)

In the equation, the billable time percentage \( B \) for the period, usually a week, is given in terms of \( H_e \) and \( H_t \), the total billable time for evaluation and treatment sessions, respectively, and \( H_p \), the total number of hours the therapist was available for work during the period in question. When the evaluation and treatment sessions average one hour, we have the special case \( \bar{h}_e = \bar{h}_t = \bar{h}_p = 1 \), and the billable time fraction \( B \) becomes:
OT/PT shops typically set a house target value for $B$ at a number greater than 60%. The balance of the time is assumed to be used for administrative chores. Note however that there are no protections that would keep the therapist from being overworked by an excessive number of appointments. The actual amount of time $T$ consumed by the therapist is some average multiple $m_e$ and $m_t$ ($m_e$ and $m_t > 1$) of the total hours billed:

$$T = m_e \cdot H_e + m_t \cdot H_t = m_e \cdot \sum_{i=0}^{n_e} h_{e,i} + m_t \cdot \sum_{j=0}^{n_t} h_{t,j} \equiv m_e \cdot n_e \cdot \bar{h}_e + m_t \cdot n_t \cdot \bar{h}_t$$  \hspace{1cm} (10)$$

The time available for billing is limited by the number of hours $H_p$ the therapist is available for work each period. The probability that the therapist will be able to book an additional appointment thus decreases as the number of appointments already booked increases:

$$p_B = 1 - m_e \cdot \frac{H_e}{H_p} - m_t \cdot \frac{H_t}{H_p} = 1 - m_e \cdot \frac{n_e \cdot \bar{h}_e}{n_p \cdot H_p} - m_t \cdot \frac{n_t \cdot \bar{h}_t}{n_p \cdot H_p}$$  \hspace{1cm} (11)$$

When $\bar{h}_e = \bar{h}_t = \bar{h}_p = 1$, $p_B$ becomes:

$$p_B' = 1 - m_e \cdot \frac{n_e}{n_p} - m_t \cdot \frac{n_t}{n_p}$$  \hspace{1cm} (12)$$
The billable time approach is favored because it can be implemented by simple the simple addition of the number entries in an appointment book. Some use spreadsheets or specialized billing and payroll software to ratio the number of appointments hosted against the number of hours a therapist was available for work. Guided by prior observation and experience, they then set an arbitrary fraction as an acceptable ratio. For example, an OT/PT facility may deem that a therapist who booked 70% of the hours they were available for work as meeting the house goal for productivity, and by extension, effectiveness.

Beyond its simplicity, the approach has the virtue that it does account for the therapist's days off. But it also has the flaw that it does not account for the amount of work associated with these billable hours, and so can be a source of dis-information, frustration, and resentment, because it makes no provisions for the equitable distribution of the house caseload, or allow for an unbalanced mix of evaluations to treatment sessions.

An automated scheduler can correct these problems by using the concept of a workload. An automated workload-based metric can track the therapist's appointment history, and use it to balance the ratio of evaluations to treatment sessions, rationally apportion the case load based on the patient's medical needs and the therapist's skillset, and equitably distribute it by location based on the caretaker's preferences, and all without the need to interact with a billing or payroll software. More importantly, a workload based scheduler increases the probability that an appointment request will be met, and so increases the access to medical care on the part of OT/PT patients.
3.4 The Workload Concept (W)

The workload concept W is similar to the concept of billable time B, except that W explicitly takes into account the total number of hours consumed by the combination of the face-to-face billable time the therapist spent with the patient, and the administrative time the therapist spent to prepare and follow-up on the face-to-face session. The workload concept W retains the simplicity of the billable time measure B, but has the advantage of being sensitive to the therapist's work hour limits when faced with multiple evaluations and treatments during the week.

Let the workload be defined as follows:

\[
W \equiv \frac{1}{H_p} (m_e \cdot H_e + m_t \cdot H_t) \equiv \frac{1}{n_p \cdot h_p} (m_e \cdot n_e \cdot \bar{h}_e + m_t \cdot n_t \cdot \bar{h}_t)
\]

Here, W is the workload for the period in question, usually a week, \(n_e\) and \(n_t\) are the number of evaluations and treatments held during this period, \(H_e\) and \(H_t\) are the corresponding total number of work hours set aside for the preparation, hosting, and reporting activities associated with an evaluation or treatment, respectively, and \(H_p\) is the total number of hours the therapist was available for work during the period in question.

When \(\bar{h}_e = \bar{h}_t = h_p = 1\), the workload expression simplifies to:
\[
W' = \frac{1}{n_p} (m_e \cdot n_e + m_t \cdot n_t)
\]  

(14)

As an example, with \(m_e = 5\), \(m_t = 1.25\), a full-time therapist who hosted 5 hour-long evaluations \((n_e = 5)\) and 12 hour-long treatment sessions \((n_t = 12)\) in a 40 hour workweek \((n_p = 40)\) will have had a workload of 100% for the week. As another example, with \(m_e = 3\), \(m_t = 1\), a part-time therapist who hosted hour-long 3 evaluations \((n_e = 3)\) and 11 hour-long treatment sessions \((n_t = 11)\) in a 20 hour workweek \((n_p = 20)\) will also have had a workload of 100% for the week.

3.5 The Softslot Concept (S)

The workload concept \(W\) permits us to introduce the important concept of **softslots**. A softslot is an appointment slot that is reserved in software, but not actually booked. Softslots can be associated with evaluation appointments or treatment appointments. An example of a softslot-based booking sequence appears in Figure 1.

Softslots protect the therapist from overwork and help balance the patient case load equitably among all therapists. Because soft-slots are reserved but not actually booked, they also preserve the ability to be displaced by an actual billable appointment. As a result, as shown in what follows, softslots significantly improve access to care by improving the odds of booking an additional patient appointment compared to approaches based only on tracking billable time.
Let the number of softslot hours \( h_{s,e} \) and \( h_{s,t} \) and the corresponding number of softslots \( s_e \) and \( s_t \) set aside for evaluation and treatment softslots in a therapist appointment schedule be defined by:

\[
h_{s,e} = m_e \bar{h}_e - \bar{h}_e = (m_e - 1) \cdot \bar{h}_e \equiv s_e \bar{h}_e \quad \therefore m_e = s_e + 1
\]

\[
h_{s,t} = m_t \bar{h}_t - \bar{h}_t = (m_t - 1) \cdot \bar{h}_t \equiv s_t \bar{h}_t \quad \therefore m_t = s_t + 1
\]

Substitution of \( m_e \) and \( m_t \) into the earlier expression for \( W \) produces:

\[
W = \frac{1}{n_p h_p} \left[ (s_e + 1) \cdot n_e \cdot \bar{h}_e + (s_t + 1) \cdot n_t \cdot \bar{h}_t \right]
\]

By rearranging we obtain \( W \) in two terms. The first one is the hard or billable appointment time \( B \), which is independent of the number of softslots \( s_e \) and \( s_t \). The second one, the soft time \( S \), dependent on them:

\[
W = \frac{n_e \cdot \bar{h}_e + n_t \cdot \bar{h}_t}{n_p \cdot h_p} + \frac{s_e \cdot n_e \cdot \bar{h}_e + s_t \cdot n_t \cdot \bar{h}_t}{n_p \cdot h_p}
\]

or

\[
W = B + S
\]
Because the softslots $s_e$ and $s_t$ are slot reservations but not booked appointments, for purposes of appointment booking, $s_e = s_t = 0$, and the soft time $S$ described by the second term of $W$ does not impact the probability of booking an appointment. The probability of booking another appointment is then given strictly by the contribution from the first $W$ term:

$$p_w = 1 - \frac{n_e \cdot \bar{h}_e}{n_p \cdot \bar{h}_p} - \frac{n_t \cdot \bar{h}_t}{n_p \cdot \bar{h}_p}$$

(20)

When $\bar{h}_e = \bar{h}_t = \bar{h}_p = 1$, $p_w$ simplifies to:

$$p_w' = 1 - \frac{n_e}{n_p} - \frac{n_t}{n_p}$$

(21)

Comparison of the expression for $p_w'$ with the one for $p_B'$ shows the important result that, except for the trivial initial case $n_e = n_t = 0$, $p_w' > p_B'$ for the same values of $n_e$ and $n_t$. This fact is due to the presence of the $m_e$ and $m_t$ terms in the expression of $p_B$, which were defined to be greater than 1. For a detailed illustration that $p_w' > p_B'$, see Figure 2 and Table 1.

Another important result is that when $\bar{h}_e = \bar{h}_t = \bar{h}_p = 1$, $W$ reduces to:
The expression \( W' = B' + S' \) separates the therapist's workload cleanly into two components, one ascribable to their billable work, \( B' \), and the other to the incidental additional work associated with providing this billable work, \( S' \).

Note that \( S' \) is expressed in terms of softslots, the number of appointment book slot reservations \( s_e \) and \( s_t \). These softslots can be displaced to a different slot when a request for an actual appointment arrives that conflicts with their current location, which is of course why \( p_{W'} > p_{B'} \). At the same time, because the softslots reserve time for work that is incidental to the time spent in face-to-face OT/PT sessions, the softslots help to protect the therapist from over-booking, and so the fear of over-work and job dissatisfaction in the absence of control over their own work schedules.

3.5.1 Softslot Scheduling Example

Figure 1 provides an example of the use of softslots when scheduling OT/PT appointments. Compared to a self-scheduled billable time reservation system, the use of computerized softslots ensures an un-biased selection of appointment slots while also tracking the therapist's workload, and so maximizes the appointment booking probability while still protecting the therapist from overwork by overbooking.
Figure 1. Softslot-based scheduling example. The cases (a)-(i) are detailed in Table 1 and Figure 2.
The book of appointments is empty in Figure 1(a). For cases (b) through (g), the probability $p_W$ of booking an additional appointment is always greater than the probability $p_B$. Once the therapist billable time has reached 65\% in (h), the odds of booking an additional evaluation or treatment are only 1 out of 20 when using the Billable Time Method, but much higher at 7 out of 20 when using the automated Workload Method. In case (i), the additional evaluation booked increases the workload to 100\%. This additional evaluation would not have been booked had the Billable Time method been used because the appointment slot requested, 3 pm Friday, would not have been available.

Table 1 and Figure 2 show that, as the number of bookings increases from (a) to (i), the probability of being a match for an additional booking is always higher for the workload method than it is for the billable time method.

### 3.6 OT/PT Model Summary

Figure 3 shows a summary of the new OT/PT patient scheduling system.

Repetition of the cycle in Figure 3 for every appointment frequency, from daily to monthly, as the calendar advances, schedules an entire OT/PT patient population at a time.

The new system uses queues to hold appointment requests and appointment bookings, and polling and prioritization to distribute them.
Table 1. Workload and Billable Time Method Scheduling Comparison. An example comparison of the progression in booking probabilities of an additional OT/PT appointment booking by a part-time therapist working 20 hours per week, and using softslots and the Workload Method against the Billable Time Method. See also Figure 1 and Figure 2.

<table>
<thead>
<tr>
<th>Case</th>
<th>Number Of Appointments In a 20 Hour Work Week</th>
<th>Workload (W')</th>
<th>Billable Time (B')</th>
<th>Booking Probabilities (pW', pB')</th>
<th>Booking Odds (EW', EB')</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a)</td>
<td>0 0</td>
<td>0%</td>
<td>0%</td>
<td>1.00 1.00</td>
<td>20/20 20/20</td>
</tr>
<tr>
<td>(b)</td>
<td>1 0</td>
<td>15%</td>
<td>5%</td>
<td>0.95 0.80</td>
<td>19/20 16/20</td>
</tr>
<tr>
<td>(c)</td>
<td>1 1</td>
<td>20%</td>
<td>10%</td>
<td>0.90 0.75</td>
<td>18/20 15/20</td>
</tr>
<tr>
<td>(d)</td>
<td>1 3</td>
<td>30%</td>
<td>20%</td>
<td>0.80 0.65</td>
<td>16/20 13/20</td>
</tr>
<tr>
<td>(e)</td>
<td>2 3</td>
<td>45%</td>
<td>25%</td>
<td>0.75 0.45</td>
<td>15/20 9/20</td>
</tr>
<tr>
<td>(f)</td>
<td>2 4</td>
<td>50%</td>
<td>30%</td>
<td>0.70 0.40</td>
<td>14/20 8/20</td>
</tr>
<tr>
<td>(g)</td>
<td>2 8</td>
<td>70%</td>
<td>50%</td>
<td>0.50 0.20</td>
<td>10/20 4/20</td>
</tr>
<tr>
<td>(h)</td>
<td>2 11</td>
<td>85%</td>
<td>65%</td>
<td>0.35 0.05</td>
<td>7/20 1/20</td>
</tr>
<tr>
<td>(i)</td>
<td>3 11</td>
<td>100%</td>
<td>70%</td>
<td>0.30 0.00</td>
<td>6/20 0/20</td>
</tr>
</tbody>
</table>
Figure 2. Comparison of OT/PT appointment booking probabilities using the Workload Method and the Billable Time Method. The cases (a)-(i) are those detailed in Figure 1 and Table 1.
Figure 3. The conceptual model for the new patient-centered, population-based, automated OT/PT appointment scheduling system. Legend: (1) Advance the calendar?
3.7 Selective OT/PT Appointment Queues

The OT/PT patient scheduling of Figure 3 uses the following queues as architectural elements to support the distribution selectivity of the new OT/PT appointment system:

1. The "Schedule Treatments" process uses the treatments queue, which contains all the treatments scheduled for within a given scheduling cycle (daily, odd, weekly, alternate week, or monthly).
2. The "Schedule First Treatment" process uses the queue holding the evaluations scheduled for this week (if the evaluation was held, try to schedule a the first in a new treat series; if not held, re-schedule as an evaluation).
3. The "Flush Treatments Backlog" process uses the prioritized treatment session request backlog queue.
4. The "Flush Evaluations Backlog (1)" queue uses the prioritized evaluation session backlog queue.
5. The "Add New Referrals" process adds the week's referrals to the evaluation session backlog queue.
6. "The "Flush Evaluations Backlog (2)" queue uses a randomized evaluation session backlog queue.

3.8 Intelligent OT/PT Appointment Routers

The queues just described provide built-in selectivity and an appointment request and appointment booking distribution intelligence. The built-in selectivity arises from the differentiation of appointment requests from appointment bookings, and the use state flags (as detailed below). This distribution intelligence arises from the switching
provided by the three enqueueing mechanisms and the three de-queueing mechanisms available to every queue shown in Figure 4 and Figure 5. The mechanisms serve as sources for new OT/PT appointment request and appointment booking arrivals, and sinks for their departures:

3.8.1 Arrival Mechanisms

*Rollovers:* These elements have been accepted as the result of calendar advancement.

*Backlogs:* These elements have been quarantined by another queue as the result of congestion elsewhere.

*Recycling:* These elements have been held over because the event they represent was not held as scheduled.

3.8.2 Departure Mechanisms

*Flushes:* These elements have been parked in another queue by action of calendar advancement and the completion of a given scheduling cycle frequency (daily, odd, weekly, alternate weeks, or monthly).

*Denials:* These elements are temporarily retained because they could not be accommodated by the next queue.

*Abandonments:* These elements have completed their journey, or exceeded their Time To Live (TTL), as determined by event repetition flags and no-show counts.
Figure 4. The abstracted decision-making routing intelligence of the appointment request and appointment booking queues. (a) Queue arrivals; (b) queue departures; (c) routing behavior.
Figure 5. The six basic queue OT/PT appointment request and appointment booking routing behaviors.
3.8.3 Queueing And Routing Example

Figure 6 and Table 2 provides an example of the built-in selectivity and intelligent distribution behavior of the five queues which serve as the basic architectural elements of the new OT/PT patient scheduling system. The referrals queue is the only source of new OT/PT patient evaluation requests. The backlog queues act as both sources and sinks of evaluation and treatment appointment requests. The evaluations queue holds evaluation bookings and is a source and sink for evaluation bookings. The treatments queue holds treatment bookings and is a source of new therapist-initiated follow-up treatment requests, and a sink for patients who have completed or abandoned their treatment series of therapy appointments.

3.9 AS IS Scheduling Space

The current OT/PT patient scheduling space is shown in Figure 7. A human scheduler books OT/PT appointments one at a time by piecing together information they cannot easily access. The scheduling output is micronetic in scale, and anthropometric in mode (Hennessey, Hullur, McPherson, et al., 2003). The input information needed by the human scheduler is held by the Patient, Caretaker, Payor, Therapist, and Administrator, as shown below:
Figure 6. The new 5-queue, OT/PT appointment scheduling system at work. The system has selection and a distribution intelligence. Legend: (1) New patient referrals queue; (2) booked evaluations queue; (3) booked treatments queue; (4) evaluation request backlog queue; (5) treatment request backlog queue.
Table 2. Example Appointment Request And Appointment Booking Routing. This table illustrates the distributive intelligence and selective switching behavior of the five queues.

<table>
<thead>
<tr>
<th>Queue</th>
<th>Fig X Reference</th>
<th>Arrival Rates</th>
<th>Departure Rates</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Rollover</td>
<td>Recycle</td>
</tr>
<tr>
<td>Referrals (R)</td>
<td>1</td>
<td>150</td>
<td>0</td>
</tr>
<tr>
<td>Evaluations (E)</td>
<td>2</td>
<td>100</td>
<td>16</td>
</tr>
<tr>
<td>Treatments (T)</td>
<td>3</td>
<td>96</td>
<td>13</td>
</tr>
<tr>
<td>Evaluations Backlog (E)</td>
<td>4</td>
<td>20</td>
<td>5</td>
</tr>
<tr>
<td>Treatments Backlog (T)</td>
<td>5</td>
<td>15</td>
<td>0</td>
</tr>
</tbody>
</table>
Figure 7. The current OT/PT patient scheduling workview abstractions. The schedule is forced to work with information outside their knowledge domain. *Legend:* (a) scheduler's workview; (b) administrator's workview.
3.9.1 Inputs:

- **Payor** (Eligibility, Pre-Authorization)
- **ReferralSpecialist** (PatientNeeds, TherapistSkillset)
- **Therapist** (Location, Availability)
- **Caretaker** (AppointmentPreferences)

3.9.2 Processing:

- **Scheduler** (Payor, ReferralSpecialist, Therapist, Caretaker, Patient)

3.9.3 Outputs:

- **Appointment** (Patient, Therapist)
- **Administrator** (BillableTime)

3.10 TO BE Scheduling Space

By transformation of the OT/PT scheduling space, the current anthropometric scheduling roles are abstracted into elements that can be processed by intelligent routers and distributed queues. As shown in Figure 8, the information needed for scheduling is captured in advance and in a reusable form under Separation Of Duties, directly from the referral specialist, the patient caretaker, and the therapist. As a result, the scheduling
Figure 8. The new OT/PT patient scheduling workviews, abstracted under Separation Of Duties. Legend: (a) abstracted scheduler interface, now fully automated; (b) abstracted reporting interface; (c) abstracted referral specialist interface, with a built-in recommender; (d) abstracted caretaker interface; (continued on next page)
Figure 8. (continued) (e) abstracted therapist interface to set the patient scheduling frequency; (f) abstracted therapist interface to capture personal vacations and days off.
output is now macronetic in scale, and automated in mode, and the input and output scheduling space is transformed into a simpler form:

3.10.1 Inputs:

- **AppointmentRequest** (Patient, TypeFlag, FrequencyFlag, AgeFlag, QueueStatusFlag, NoShowCount)

3.10.2 Processing:

- **Schedule**(AppointmentRequest)

3.10.3 Outputs:

- **Appointment**(Patient, Therapist)
- **Reports**(Outcomes, Utilization, Payments)

The fields that are not self-explanatory are:

*TypeFlag*. Evaluation or Treatment. A primary driving or forward flag.

*FrequencyFlag*. At the end of every day, the scheduler processes all daily requests, if any. At the end of every week, all weekly and alternate week (every other week) requests. At the end of every month, all monthly requests. The forward roll
polling approach will flush them out based on their relative age and frequency priorities.
A primary or driving flag.

AgeFlag. Incremented after every failed scheduling attempt. Never reset, so as to
force-flush it out of the system sooner. Used to switch therapists at the same location,
and consider the main location over the preferred location. A primary, driving, or
forward flag.

QueueStatusFlag. Can be queued (and so in one of the backlog queues), booked
(and so in one of the appointment queues), completed, or abandoned. A primary flag.

NoShowCount. Incremented after every no-show or cancellation. Reset to zero
after every held appointment. A secondary, book-keeping, lagging value.

3.11 Queue Polling And Processing

As the calendar advances and the queues in Figure 6 are polled anew with every
new scheduling cycle (daily, odd, weekly, alternate weeks, or monthly), the elements
within the evaluation request, treatment request, evaluation booking, and treatment
booking queues in Figure 6 are presented to the automated scheduler in either a random
or a prioritized fashion.

The two queues holding the book of appointments, the initial OT/PT evaluation
bookings (Figure 6(2)), and the follow-up treatment bookings (Figure 6(3)), are presented
to the automated scheduler in randomized order at the beginning of every new scheduling
cycle. The randomization ensures that appointments scheduled for a Friday, for example,
are not always at a disadvantage over appointments scheduled for a Monday.
In the case of the two backlog queues, the initial OT/PT evaluation request backlog queue (Figure 6(4)) and the follow-up treatment request backlog queue (Figure 6(5)), the backlogged appointment requests are grouped and ordered in descending order based on the number of previous unsuccessful attempts to schedule the appointments. The appointment groups with the greatest number of un-successful prior attempts appear earlier in the queue than those with fewer prior attempts. Within each group, the order of appointment requests is randomized anew at the beginning of every fresh scheduling cycle.

The paragraphs that follow provide additional details on the runtime polling of the queues in Figure 6.

3.11.1 Booked Treatments Queue Processing

The treatments queue in Figure 6(3) is the queue with the highest precedence, and so is the first one queried by the scheduler. This queue contains the treatment bookings for a given scheduling cycle (daily, odd, weekly, alternate weeks, or monthly). This queue acts as a treatments appointment pump. Additional treatment appointment bookings are added to the queue as the calendar advances through the treatment plan set by the therapist. The treatment session is rolled into the ensuing scheduling cycle after calendar advancement establishes they have been hosted (or not). For every scheduling cycle frequency, the individual bookings in the treatments queue are presented to the automated scheduling engine in random fashion so that appointments held later in the day
or later in the week are not always at a booking disadvantage compared to appointments held earlier in the day or week.

When accessed at runtime, the software uses no-show flags and repetition counts to decide what to do with the treatments queue booking. In a simulation this decision is emulated. The software logic first decides, based on biased random picks specified by the model settings for percentage of appointments that are not held because of patient or therapist no-shows or cancellations, whether or not the appointment was held as scheduled. If it was, the program flags the appointment as billable, resets the no-show or cancellation flag for the appointment to zero, and increments the number of times that appointment was held within the appointment series that treatment represents. If it was not, the program first increments the number of times the appointment was not held in the past due to cancellations and no-shows, and then checks whether this count now exceeds the cut-off specified by the hospital in the runtime model. If the cutoff has been exceeded, the appointment is flagged as abandoned, and no attempt is made to reschedule it later. This abandonment behavior supports the hospital practice of clearing repeatedly unused appointments with follow-up educational letter. The letter serves as a reminder on the importance of honoring appointments, and provides a phone-number to initiate a new scheduling request.

If the scheduling effort has not been abandoned, the automated scheduler next decides whether a follow-up appointment is needed. In the absence of a therapist over-ride, this decision is made by comparing the number of times the appointment was held against the number of times specified by the treatment plan. In the real-world, the therapist is free to extend or curtail the number of treatment sessions needed within a
given treatment series depending on patient progress, and the system supports this
decision also. The simulation emulates this discretionary therapist behavior by assigning
a random number of repeat treatment sessions needed to the first appointment in a series.

The capability to extend or curtail appointments based on the outcomes of the
appointments held in the treatments queue in a series is an important feature of the
scheduler. As will be shown in the case study below, it was the need to reserve a series
of appointments by blocking appointment slots weeks in advance, in a way that would let
a patient return if needed the following week and visit with the same therapist at the same
location during the same weekday time slot, that made the reporting of therapist
availability so in-effective.

The appointment booking logic is executed next. This logic matches the patient
appointment preferences of the patient with a suitable and available therapist. It is
described in detail in a later section.

3.11.2 Treatment Requests Queue Processing

The queue with the second highest precedence within a queue polling cycle is the
treatment backlog queue, Figure 6(5). The treatment backlog queue services backlogged
treatment appointment requests. These are the scheduling requests for treatment sessions
held originally in the first queue in cycles past, but which could not be honored in the
immediately preceding and, possibly, earlier cycles, because, as appropriate for the logic
behind the initial request, which is described in greater detail below in the section on
therapist selection, no available therapist at a given location, or no available appointment
slot at the main location, could be identified at the time of the initial and subsequent requests.

The elements within the treatment backlog queue are prioritized in groups. The grouping is based on the number of previous attempts to flush a given appointment from the queue. The groups in the queue are sorted and presented to the scheduler in descending order. Within each group, at the time of the next scheduling attempt, the elements are accessed in random order.

The booking logic that flushes appointments from the treatments backlog queue by matching patients to therapists is described in detail later.

3.11.3 Booked Evaluations Queue Processing

The third queue visited by the scheduler holds the evaluations that had been scheduled by the previous scheduling cycle to be held during the preceding cycle. This queue is shown in Figure 6(2). The initial scheduler behavior and decision making when servicing the evaluations queue is similar to that of the treatments queue. The behavior eventually diverges because, unlike treatment, a patient evaluation is held only once, at the time of the patient's initial referral by a physician.

In similar fashion to the treatments queue, the scheduler when first decides whether or not the evaluation was held as scheduled. If it was not, the scheduler again decides, in similar fashion as it does with treatment requests, whether to abandon its scheduling effort, or instead add the request to the evaluations backlog queue. If it was, the evaluation appointment is recorded as billable. Setting this billable flag is an
important event for the OT/PT facility. For one, it marks the capture of a patient into its cycle of care. In addition, it also marks the first time the hospital will be compensated for all its earlier effort with the processing of the physician referral slip, medical needs and payor identification, and attempts at patient contact and scheduling.

Following the evaluation session, the therapist prepares a written report for review internally and by the physician. The preparation of this report is time consuming, even though it takes advantage of specialized template-based software. Because the OT/PT facility can only bill for face time with a patient, neither the staff nor the therapist receives no billable time credit towards their billable time for the week for the man-hours invested in the preparation, recording, and dissemination of this report, or for the time spent with follow up consultations with the referring physician. The hospital recovers the costs from before and after hosting the OT/PT evaluation only indirectly, from the fact that the hospital’s typical billable rate for the evaluation is significantly higher that the average billable rate for a face-to-face follow-up treatment session with the patient. The cost recovery by means of this higher rate for the session also only indirectly addresses the issue that, based on hospital staff estimates, as many as 50% of all new patient referrals never complete their initial evaluation. The hospital has no means of recovering the cost associated with the several man-hours the schedulers and other back-office personnel may have expended trying to convert a referral slip into an evaluation that actually took place, and so is billable.

Because the report is time-consuming, but the therapist earns no house credit for the work towards their 65% billable time quota for the week beyond the hour they spent face-to-face with the patient, therapists are understandably sensitive to the issue of
finding themselves overworked from an unlucky schedule draw that imposes upon them an un-balanced mix of evaluation and treatment sessions for the week. On occasion, in such situations, the therapist is able to take advantage of surprise no-shows and last minute cancellations, some 25% of all scheduled appointments, according to staff estimates, to help clear their work backlog, but not reliably so.

As will be described in greater detail in the case study portion of this work, to appease the therapist's concern with over-booking, the administration of the OT/PT facility over time introduced and institutionalized the practice of letting the therapists maintain their own book of appointments, and, on a weekly basis, report their weekday and time-slot availability for the following two weeks for new patient evaluations, and, as a distinct category, their availability to host blocks of treatment sessions.

Part of the rationalization was also that the therapist, by developing a relationship with the patient and the patient's care-taker, and being in close personal contact with the patient, usually on a weekly basis, could freely decide to extend, curtail, or adapt the patient's treatment sessions in a series, depending on the patient's progress and needs, and also at the same time listen to, and accommodate the care-taker's personal and family scheduling conflicts, without having to worry that a previously un-scheduled follow-up appointment for the following week for the patient's usual weekday and time-slot was not available because a scheduler had already assigned it to another patient.

In this context then, on the surface, the approach was friendly to the patient, agreeable to the therapist, simple to their supervisors, tolerable by the schedulers, and reasonable to the administration. In practice however, no one was pleased or well-served.
In exchange for the scheduling freedom, the only constraint or control imposed by the administration on the therapists was the 65% billable time rule. The number seems to have been arrived at by consensus building following consultation with internal administrative estimates of productivity and overhead costs. The 65% rule provided an easily measured internal control on the part of the therapist's supervisors, who are usually based at the same OT/PT service location as the therapist they supervise. The supervisor could review the therapist's productivity locally before forwarding to the central location by campus mail or faxing. The rule also enabled the therapist to schedule the structure and flow of their own work-day and work-week to suit their personal scheduling needs and preferences. At least on the surface, it provided an adequate incentive and accountability for therapist to report and so make known to the schedulers on a weekly basis what open slots they see in their appointment book. It even let the therapists retain fine control over what they reported, and so over their weekly workload, by letting them differentiate in their weekly availability report to their supervisors, schedulers, and unit administrators, between the one-of appointment slots they chose to make available for evaluation sessions, and the ones for treatment sessions.

The aggregated information at corporate was poorly summarized because difficult to interpret. Only laboriously entered into Excel spreadsheets, with error-prone transcription from the written sources, hard to maintain and find on disk, version control when of changes, difficult to chart and share, and don't allow filtering and querying, or selective sub-totaling and period-over-period comparisons other than by time-consuming color-coding of hand-selected columns and rows, and the entry of difficult to maintain macros and formulas.
The therapist's report may say that the patient would benefit from a series of treatment sessions, or yet that no treatment is warranted. In a typical case, if at all possible, both the hospital and the patient seem to prefer that the follow-up treatment sessions necessary to book from their own book, or gives the patient, or more properly the patient's care-giver, some literature with instructions to call in for further scheduling. The patient does not have time, and neither the window personnel at the front desk don't have the information. The needs to contact the physician, obtain third-party payment authorization, consider options, and confer with family members all contribute also to the uncertainty associated with the scheduling of follow-up treatment sessions. The patient may have to make personal arrangements, including the psychological acceptance of the need for follow-up treatment, and the need to adjust their monthly budgeting or cash-flow when required to pay directly for services, all lead to a situation in which the scheduling of follow-up treatment sessions is not any more easily accomplished than the scheduling of an initial evaluation session.

The scheduler mirrors this behavior by assigning a secret random number of follow-up treatment sessions to the first treatment in a series before adding the request for the initiation of a treatment series to the backlogged treatments queue described earlier. As described later, this number is used in the detailed logic which matches the patient avatars in the evaluations queue to the therapists avatars eligible and available for scheduling.
3.11.4 Evaluation Request Queue Processing

The fourth queue is for backlogged evaluation requests. These are the evaluation requests that could not be booked at the time of the patient's initial referral. This queue is shown in Figure 6(4). The items in this queue are aged after every un-successful scheduling attempt. Older items have precedence over the scheduling of an evaluation for any subsequent referral arrivals. However, to keep the river flowing, although they have precedence, they do not prevent luckier later referrals from being converted to booked evaluations before they themselves have been booked.

3.11.5 New Patient Referrals Queue Processing

The fifth queue contains the referrals in the form of patient avatars which arrived during the preceding week. This queue is shown in Figure 6(1).

The order of arrival of the new referrals placed in this queue was implemented so as to follow a Poisson-distributed arrival event model. The Poisson distribution kept the arrival of the next referral is independent of the previous one, supplied a constant rate of new referral arrivals that was independent of elapsed time, and provided independent inter-referral arrival times which followed the same exponential distribution (Bhat and Basawa, 1992; Evans and Olson 2003). The new patient referral arrival rate was set to be configurable at run-time. Most experimental runs were carried out with an arrival rate of 200 new patient referrals per week, the rate reported by the OT/PT administrative staff as typical of any given week.
The new referral arrivals in Figure 6(1) were disposed-of in a matter designed to mimic their actual fate at the OT/PT practice. A fraction was abandoned because the patient did not follow-up or went elsewhere (Figure 6(1)). A second fraction was successfully booked at the end of the next weekly scheduling cycle as an initial OT/PT patient evaluation (Figure 6(2)). A third fraction was added to the backlogged evaluations request queue (Figure 6(4)).

3.12 Discussion

The following sections provide a brief discussion of the functioning of the new OT/PT patient scheduling system within the context of the daily functioning of an OT/PT division that is part of a large hospital. Three issues are addressed: the size or planning horizon of the book of appointments, the preservation of Continuity Of Care under automated, and the handling of reschedule attempts under therapist and caretaker balking behavior.

3.12.1 Small Book Of Appointments

The appointment book in the new scheduling systems is very small. It consists of only the next set of booked appointments for a given scheduling cycle frequency (daily, odd, weekly, alternate weeks, or monthly). As a result, the book of evaluation and treatment appointments shown in the queues of Figure 6(2) and Figure 6(3) is very short.
and stubby. It contains only the evaluation and treatment appointments that have been booked during the last scheduling cycle.

The advantage of the small book of appointments is that it always remains responsive to daily events. There is no pre-booked set of appointments weeks and months into the future which need to be updated, or which could conflict with today's needs, events and decisions. Appointment cancellations, no shows, holidays, and therapist vacation and days off can all be considered and incorporated the next time the affected scheduling window is activated for scheduling. There is no need to cascade changes or propagate bookings, and so also no possibility of making errors in the process. New referrals and changes in the therapist's intervention plan and in the patient's medical needs can also incorporated on short notice. All that is needed is that new referrals be added to the referrals queue, and that the therapist report whether or not this week's appointment was hosted as scheduled or not, and whether the therapist wants the computer to schedule the patient again for the following week. The computer does the rest.

For example, if the appointment was for an evaluation, and the patient did not show up, the scheduler will attempt to reschedule the evaluation, as long as the patient has not exceeded its no-show limit. If the scheduler succeeds, the evaluation is scheduled for the next week with an incremented no-show count, but an un-changed age. If the scheduler fails, the failed appointment will be added to the evaluations backlog queue with an incremented no-show count and an un-changed age. In the case of a treatment, if the appointment is honored, the therapist is free to decide whether to discontinue treatment or request a roll of the treatment appointment as had been anticipated by the
patient’s treatment plan. If the therapist decides to roll the appointment, the automated scheduler inspects the frequency flag, and books the appointment accordingly. If the frequency flags says the appointment was part of a treatment series to be held every other week, the automated scheduler will attempt to book the same weekday, time, and therapist (and so implicitly the same location) two weeks out. If it succeeds, we’re done. If it fails, it increments the age count and adds the prospective appointment as a treatments request to treatments backlog queue.

3.12.2 Continuity Of Care Under Automation

The chaining of OT/PT appointment scheduling in the new OT/PT patient scheduling system through the referral, evaluation, and treatment stages follows the natural hierarchy of OT/PT appointments: referrals become evaluations, which become a request for an initial treatment session, which become a stream of recurring follow-up treatment appointments.

To ensure high throughput under automation, the referral, evaluation, and treatment stages must be polled and flushed in the reverse order of their natural hierarchy: first recurring treatment appointments must be processed, then the initial treatment session following an evaluation booked, then an attempt made to purge the backlogged treatment requests queue and the backlogged evaluation requests queue, and finally the new referrals queue purged.

The reverse polling also ensures Continuity Of Care: the same therapist who hosted the patient's initial evaluation will be preferentially assigned the patient's treatment
series, and the therapist currently hosting a patient's treatment series will not be substituted.

When booking the evaluation for a new patient referral, the strategy is to try to book a therapist at the caretaker's preferred location. The scheduler must first determine if there is at least one therapist at the caretaker's preferred location who has the OT/PT designation and sub-specialty skillset to help the patient. If there isn't at least one, the automated scheduler automatically attempts to schedule the evaluation at the main location, at which there is a guaranteed that a therapist with the requisite skillset exists.

If the preferred location has at least one therapist with the requisite skillset, but all such therapists exceed their workload cutoff by booking the evaluation, the automated scheduler will keep trying for a given number of weeks in the hope that a therapist does become available. The acceptable wait period must be determined by the therapist in consultation with the caretaker. If there is still no therapist available for booking after the acceptable wait period has elapsed, the automated scheduler also searches for a therapist at the main location who can help the patient with the initial evaluation. From then on, if the scheduler is also not able to book the evaluation at the main location, the following week the automated scheduler will always try both, first the preferred location, and then the main location, until the evaluation is finally booked. Each time the referral has to wait, its scheduling priority is increased.

After the evaluation is held, if the therapist determines that there is a need for treatments, the automated scheduler is notified. To help maintain Continuity Of Care, the computer will first try to book the same therapist who hosted the initial evaluation, regardless of this therapist's location. Only if the therapist cannot be booked for a
treatment series because her workload limit would be exceeded, the request has aged out, or the caretaker has changed their preferred location, will the computer attempt to book a first treatment session with a different therapist, initially at the caretaker's preferred location. If the computer does not initially succeed, the wait flag for the appointment is incremented to increase the priority of the booking request during the next scheduling cycle. Only after the wait window for a potential roll-over has been exceeded will the main location be considered again. In other words, once a treatment series has been initiated, the computer will continue to re-book that therapist, and so preserve Continuity Of Care, for as long as the wait period is not exceeded, all the while incrementing the weeks waited flag at the end of every scheduling cycle to age the request and so increase its priority.

Figure 9 illustrates the Continuity of Care preservation model under OT/PT scheduling automation. In figure 9(a), evaluations from new referrals are booked at the caretaker's preferred location if possible. If the evaluation therapist cannot be booked, an attempt is made to book an alternate therapist at the caretaker's preferred OT/PT satellite location, as shown in Figure 9(b). If in addition the wait period for the initial treatment session has been exceeded, the computer also attempts to book an alternate therapist at the hospital's supra-cell main OT/PT location, Figure 9(c).

In a variation, if the preferred location cannot be booked because no therapist can service the patient's medical condition, the computer switches to trying to book the evaluation at the main hospital's location, Figure 9(b).

If the preferred location cannot be booked because all suitable therapists have too many bookings already, a wait flag is incremented to increase the priority of the
Figure 9. An automated OT/PT appointment booking strategy aimed at providing Continuity of Care. (a) The therapist who conducted the patient's initial evaluation is booked first. When wait times become detrimental to the patient, in (b) a therapist at the caretaker's preferred satellite location is booked. As a last resort, in (c) therapists are selected at the main location, which serves as a fall-back supra-cell.
evaluation during the next automated scheduling cycle. When by incrementing this flag the number of weeks exceeds a cutoff set by the therapist in consultation with the patient's caretaker, the computer from then on will attempt both the preferred location and the alternate location, and continue to increment the wait flag on failure.

If the scheduled evaluation is canceled or not held because the patient did not show up, a now so flag is incremented, and a new attempt is made to re-schedule the patient with the same wait priority as was used to book the original appointment.

Once the evaluation is held, the computer will attempt to book the same therapist who hosted the evaluation, regardless of the therapist's location.

3.12.3 Balking Behavior

We can also account for two types of balking behavior, on the part of the therapist, and on the part of the patient's caretaker.

The balking by the therapist occurs when the therapist curtails the anticipated treatment series by saying no additional treatments are warranted, or extends the treatment plan beyond what had been anticipated earlier. This late decision has no scheduling impact echo on a pre-existing book of appointments because there is no book of appointments scheduled in advance. If no additional appointments are needed, the scheduler will find the next-action flag set to none, and will do nothing. If the referral-evaluation-treatment appointment sequence is to be continued, the automated scheduler will find the next action flag set to schedule. The therapist can also change the frequency of the appointment, for example from every other week to monthly or vice-versa. In this
case, when the automated scheduler inspects the frequency flag during the next
scheduling cycle, it will find it re-set, and automatically attempt to schedule the treatment
for the following week, for two weeks out, for one month out, or for the next day, as
needed.

The balking behavior of the caretaker expresses itself when a caretaker makes a
change to their location, weekday, daytime, and timing preferences mid-stream through
the referral, evaluation, and treatment processing hierarchy. The caretaker simply enters
their new preferences in the caretaker preferences website, or tells a human scheduler,
who does the same. The next time the appointment request comes up for scheduling (for
example at the end of the week), the appointment will be scheduled based on these new
preferences. Again on success, the now show flag is reset to zero, the age flag is
retained to preserve the appointment's scheduling priority, and the other bookkeeping
flags for the next action and billable status are also updated. On failure, the request is
aged and added to the backlog request queue.
Chapter 4 - Case Study

An action research case study was conducted on-site at the OT/PT division of a major regional hospital which specializes in the care of children. The aim was to identify the AS IS functioning of the OT/PT department, and then propose a TO BE that incorporates the new OT/PT appointment scheduling system developed in the preceding chapter. This chapter describes the AS IS environment. The TO BE transformation is detailed in the next chapter, Chapter 5.

4.1 OT/PT Division Description

The OT/PT division studied has its main offices on the main campus of a major regional hospital which specializes in the care of children. The main campus is centrally located in a 15-county, 25-30 mile radius Metropolitan Statistical Area (MSA). The MSA is home to about 2,000,000 people. 90 percent of all the child patient visits at the hospital are paid for by Medicaid (Craig and O'Farrell, 2007). The hospital received more than $91 million in Medicaid payments last year, about 42 percent of its $192 million total revenue (Craig and O'Farrell, 2007).

The OT/PT facility studied hosts some 120 therapists, about 45% OT and 55% PTs. The therapists are assigned to any one of 10 OT/PT area service locations, including the main location, which functions as the administrative center and supra-cell OT/PT appointment location.
The main campus has 52 therapists, the largest contingent of OTs and PTs. The main campus location serves as the supra-cell central administrative unit. It hosts OT/PT appointments for patients from anywhere within the hospital's MSA service area. These patients may have other business at the hospital, or are transported from within the hospital. The main location also houses the majority of the schedulers and nearly all of the back-office personnel. The balance of the therapists is fairly evenly distributed at 9 of the hospital's satellite OT/PT service locations in nearby communities and adjoining counties.

The remaining OT/PT service locations are fairly evenly distributed throughout the hospital's service area. The largest satellite facility has 17 therapists, and the smallest only 4. The satellite facilities are needed because of the repetitive nature of the OT/PT appointments. OT/PT therapy can extend over several months, patients strongly prefer OT/PT facilities that are physically close to the patient's school, their home, or the parent's place of employment. The facility of choice is preferably no more than 10 miles away (Whittaker, Adkins, Phillips, et al., 2004). Table 3 shows that the OT/PT facility blankets its 25-30 mile radius MSA service area with its 9 satellite facilities in a way that keeps at least one of the OT/PT satellite service locations within 10 miles.

4.2 On Site Visits

A series of about 20 in-person visits took place on site at the main OT/PT facility over a period of one year. The visits held on a weekly or semi-monthly basis, and consisted of meetings which lasted about an hour each. The meeting participants varied.
Table 3. Lookup and comparison table for the number of OT/PT satellite locations needed for a given hospital service radius R and patient travel distance r. The number of locations for a given service radius was computed from ratios of areas. About 9 satellite locations are needed to cover a supra-cell service radius R of 25-30 miles so that the patient travel distance r does not exceed 10 miles.

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The meeting participants included the facility director, the senior therapist coordinator, the unit's designated technology facilitator, a physician referral slip specialist, and a handful of the schedulers and therapists.

There were also guided tours of the OT/PT appointment areas and back-office operations, walk-throughs and demonstrations of the patient scheduling cycle, and the observation of several patient arrival and departure cycles in the reception lobby.

4.3 Daily OT/PT Facility Functioning

As a major facility associated with a large hospital, the OT/PT division sees the full complement of patient needs, and has a full range of supporting services available. At the risk of over-generalizing for the sake of brevity, the next few paragraphs describe some of the important aspects of the OT/PT patient referral, evaluation, and treatment steps that are relevant to an understanding of the constraints and benefits of the new OT/PT patient scheduling system developed in this study.

4.3.1 New Patient Referrals

New patient referrals take the form of a referral slip for an initial OT/PT evaluation. The request is a medical prescription signed by the patient's primary care physician. The patient is free to take their referral slip to any medical facility of their choosing.
In most instances the referrals consist of the submission of a standardized one-page patient referral form distributed in advance by the hospital to area physician practices. This form is completed, signed and dated by the physician, and then faxed in as a courtesy to the patient from the physician's offices. The referral slip is occasionally mailed in by the patient, or hand delivered, after initial phone inquiries. Some referrals come from directly other medical units within the hospital. Beyond faxing, there is currently no email or other electronic means of transmittal of the information on the form, such as a secured website.

The hospital in this case study competes with other OT/PT medical providers in town for new patient referrals from physicians on the basis of (a) name-brand and quality perception; (b) its established community presence and specialized history as a pediatric hospital; (c) its imposing physical plant, and an established community presence at its local service satellite facilities; (d) free parking, urban setting, and convenient access to public transportation; and (e) physician relationships cultivated over time.

4.3.1.1 Referral Qualification

When a new patient referral is received, an attempt is made by the OT/PT office staff to make initial contact with the referring physician and the patient's caretakers, as appropriate to the situation. The purpose of the follow-up is to help qualify the referral: better identify patient needs, ask about the care-taker's weekday availability and location preferences, and establish payment and insurance re-imbursement options.
Often there are repeated rounds of phone calls with the patient's caretakers and primary physician. Several additional calls are typically needed to obtain third-party authorization for services and validate payment and insurance re-imbursement options. As appropriate, beyond the patient's family, and private health insurers, government programs, sliding-fee, and charity-subsidized payment options are also considered. Repeated calls may also be made to the physician's offices seeking clarification on one issue or another.

The back-office personnel expend a considerable man-hour effort at this early stage of the referral, including as needed during the evenings and on weekends. They may also resort to mailing letters with forms and informational literature. The back-office personnel engaged at this stage includes a team of four or five schedulers, as many insurance paperwork processors, one or another therapist consulted informally in-house, and one or two of the specialized in-house referral slip specialists who are charged with interpreting the physician's referral slip.

4.3.1.2 Referral Interpretation

The referral interpretation step is regulated. Just as a pharmacy prescription can only be filled by a licensed pharmacist, the interpretation of the OT/PT patient slip can only be performed by specifically designated personnel, the referral slip specialist.

The interpretation of the referral slip consists of identifying the best suitable evaluation and treatment resource for the patient, either a therapist trained and licensed as an Occupational Therapist (OT), or a therapist trained and licensed as a Physical
Therapist (PT). On occasion the referral specialist may determine the patient may be better served by another medical specialist, for example a speech pathologist.

To make the initial OT or PT assignment, the specialist must review and interpret the medical intent of the physician referral slip. Based on the intent, the specialist makes the initial assignment to either an OT or PT therapist heuristically, by drawing on her professional experience and training, and the detail particulars of the referral slip.

The house-supplied referral form, if available, is helpful at this stage. The form has sections with checkboxes for a tentative diagnosis, and fields for any specific medical issues that may be troubling the patient. Other sections list precautions for therapy, special patient needs, and treatment modalities to be used. Not all form sections will necessarily have been checked or filled in.

Examples of diagnoses listed on the form are Erb's palsy, arthrodesis, and muscular dystrophy. The specific medical problems are labeled for example "activities of daily living," "gross motor skills," or "range of motion." Precautions could be flagged to alert the presence of a continuous feed or IV line, or the dependency on a ventilator. Special patient needs could be for example the need for serial limb splinting, or the need for a wheel-chair. Cold and hot packs, ultrasound, and whirlpools are examples of modalities to be used.

4.3.1.3 OT Or PT Therapist Referral Assignment

The initial assignment of the referral to an OT or PT therapist, or one of each, is very inefficient. The OT/PT facility generates an average of 30 new patient referrals per
day. But no record is captured and stored in a computer on whether an OT or PT assignment was made, given the individual patient's case details. As a result, there is no database to query that could be used with subsequent referrals that could be used to more quickly determine how patients with similar medical conditions was resolved in the past. The assignment to either an OT or PT, or both, relies entirely on the personal knowledge of one of the two in-house referral slip specialists.

The patient's referral is eventually transcribed into the hospital's enterprise software, and forwarded to the scheduler for the scheduling. The patient's OT/PT therapy sessions are of two types, an initial evaluation, and a series of follow-up treatments, and the scheduler must schedule accordingly.

4.3.2 OT/PT Therapy Sessions

OT/PT therapy sessions are typically scheduled to begin at the top of the hour. The duration of the visit can and does vary based on the purpose of the session and the age of the child patient, but in general terms it can be said to last an hour. A few patients are transported internally from the hospital's clinical floors, but most are ambulatory patients.

Because the hospital specializes in care of children, most every patient is accompanied by a parent or care-giver, and on occasion other family members. The patient escorts typically also remain with the patient during the therapy session. The therapist uses their presence to advantage to educate them on home-drills to be practiced between OT/PT appointments.
In most instances, currently the therapist will personally meet and greet the patient and the patient's caretakers in the reception area, and also see them off.

The evaluation and treatment sessions are typically held on a floor mat in a corner of a large common treatment area, but also, as warranted by the patient's individual case, in private rooms. There is a sufficient number of private rooms and corner treatment areas to enable them to be used on a more-or-less ad-hoc basis, without the need to tie a specific patient appointment to a room. The private rooms are reserved informally by cross-off door notice lists, and by daily and standing arrangements between the therapists and the schedulers.

Evaluation devices and therapeutic toys are kept in a storage room, and are retrieved by the therapist by hand or from a cart as needed.

The therapist has ready access to wall clocks, but does not have access to a computer in the treatment area.

At the end of the therapy session, as the therapist accompanies the patient back to the lobby, the therapist may linger with the patient and the patient's caretakers. Depending on the situation, it also is at this point that follow-up arrangements for subsequent appointments are attempted to be finalized.

In the case of an initial evaluation, the next appointment, for a treatment session, may be left open, until after the therapist has filed her evaluation report.

After a follow-up treatment appointments anticipated by the treatment plan, the therapist may also decide, at the end of every session, whether or not to host a standing appointment the next week, or skipping it. Or yet the patient may at this stage let the
therapist know that they will not be available the following week, or the week after that, because of conflicts with other personal matters.

When the therapist returns to the office area, she makes entries to update the patient's case file, and bill for the OT/PT session.

The paragraphs that follow provide additional information on the initial OT/PT patient evaluation, and the follow-up OT/PT patient treatment sessions.

4.3.2.1 Initial OT/PT Patient Evaluation

The initial OT/PT evaluation is held first. It consists of a single, usually hour-long session. First, the therapist reviews the patient's referral information and related medical history. Then, based on an examination that considers answers to questions, clinical observations, and the results of structured tests, the therapist makes a medical assessment.

The OT/PT evaluation establishes baseline conditions as of the day of the evaluation, and informs the primary diagnosis, the prognosis, and the treatment recommendations that are pertinent to the patient as an individual.

Examples of items considered during the evaluation session include things like the patient's overall posture, sense of balance and orientation, cognitive capacity, lung performance, muscle strength, the range of motion of joints, and gross and fine motor control.

The results of the session are captured with specialized, templatized software, and shared with the patient's physician and care-takers in the way of a report.
4.3.2.2 Follow-Up OT/PT Patient Treatments

Based on the results of the initial OT/PT evaluation, and consultation with the patient's physician, a series of follow-up treatment sessions may be deemed medically warranted and appropriate by the OT/PT therapist. The treatment sessions are typically held weekly or every other week, but daily and monthly regimens may also be prescribed.

The decision on the number, nature, and frequency of the patient's follow-up treatment plan is made by the therapist based on the individual case presented by the patient.

The treatment decision is also informed by the payment and third-party pre-authorizations. For example, the patient's insurance company may only have authorized three OT/PT sessions every six months. The treatment plan may include hands-on techniques such as stretching or kneading, hot and cold packs, or electrical simulation. The therapy may also use games or drills with ordinary or specialized toys, as well as the introduction assistive technology such as braces, splints, and walking devices.

4.4 Schedulers

After the physician referral slip specialist has made the initial determination to assign the patient to either an OT or PT therapist, or both, the case is handed to a scheduler. The scheduler then attempts to contact the patient, or more properly in the context of this study, the patient's parent or care-giver, to schedule the initial evaluation.
The contact is typically made over the phone, and usually requires repeated attempts, including on evenings and weekends.

The scheduler does considerable work at this next stage to match the patient to a therapist. She must take into account the patient's preferences, and the skillset and current book of appointments of an available therapist.

One of the scheduler's first steps is to ask about the patient's preferred location for the initial evaluation. For continuity of care reasons, in most cases, the evaluation location will also be the location for subsequent treatment sessions. But the patient's caretakers may choose to have the evaluation done at the main facility, on the same day as a hospital visit for another purpose, and then change the location so that the treatment series will take place closer to home. The location options are the hospital's central location, or at any of its 9 satellite service facilities, depending on what the patient believes to be more convenient.

The scheduler must also determine which weekdays and time-slots would be agreeable to the patient's caretakers. Many patients are very specific about their location, weekday, and timeslot selections. They will consider only limited options, typically no more than two or three slots in any given week.

The patient's scheduling options are somewhat constrained by the fact that the OT/PT division currently offer appointments beginning at 8 a.m., but it does not make weekend or late evening appointments after 5 p.m. available as options to the patient. The patient's caretakers in turn may only be able to come after school or work, and may have conflicts with other family members or planned events.
After collecting scheduling information from the patient, the scheduler must next turn around and identify a specific therapist who has the proper OT or PT designation and skillset subspecialty which are a good fit for the patient. Currently there is no record of these skillsets by location, and so no means for the schedulers to browser or search this information in electronic format. The scheduler must obtain and accumulate information about therapist sub-specialty preferences from informal channels. Of course, the therapist the scheduler identifies must have an OT/PT appointment slot available at the location, weekdays, and daytimes specified by the patient's caretaker, and with the sawtooth re-scheduling frequency pattern (daily, odd, weekly, alternate week, or monthly) sought by the therapist according to her treatment plan.

4.4.1 Scheduling And Re-Scheduling

The uncertainty and time associated with the scheduling and re-scheduling of subsequent appointments is a sensitive issue for the department. Because each therapist maintains her own appointment book, she can accommodate requests for the re-scheduling of appointments on the spot at the close of a session with the patient fairly easily, assuming the patient's caretakers does not report an upcoming conflict. At other times, the therapist's involvement is still needed, but the therapist may not typically as easily reachable. This poses a problem for the OT/PT department. The idle chat time in the lobby, and disconnects and interruptions distract the therapist from their regular duties, and the therapist's time in the pursuit of the request to cancel or reschedule an appointment is not billable.
To schedule or reschedule an appointment at other times beyond the time of their appointment, the patient must call and navigate the hospital's phone tree to speak with an OT/PT patient scheduler. If the scheduler cannot address the issue on the spot, she calls or sends a message to the therapist in question. The therapist may well be based at a satellite facility. The therapist must then confirm the change or answer the questions with a return phone call, or a internal message to be forwarded by one of the schedulers.

The department uses a phone tree that lets the patient's care-takers talk to a scheduler and make cancellations and re-schedule requests known. However, this phone tree is only available during regular business hours. Outside of business hours, the patient can only leave a recorded message.

To facilitate the scheduling and re-scheduling effort, the schedulers often have to both initiate and return patients after hours and on weekends, from their own homes.

4.4.2 Caretaker Appointment Preferences

When scheduling an OT/PT therapy session, the scheduler must establish which appointment locations, weekdays, and times would be convenient and acceptable to the child patient's caretakers. From discussions with the hospital staff, the patients tend to have favorite appointment choices. They tend to want to cluster to appointments later in the week, and later in the day, often after the patient's school lets out. The appointments later in the week seem to be preferred because the patient's parent sees their work-related issues as taking precedence earlier in the week. Appointments later in the afternoon seem
to be preferred because they would be after school, and the parent can leave work early and go directly home from the appointment.

Much to the distress of the scheduling and medical staff, a surprising number of patients are willing to wait a surprising long time, some 30 days to 45 days, before they will come in for the initial OT/PT evaluation. Here the roadblock issues appear related to first having to resolve insurance coverage, cash flow, and payment options, some acceptance and resignation of the patient's chronic condition, and ordinary personal scheduling issues like scheduling the appointment around business trips and soccer practice. Some the patients may abandon treatment series before completing them. If phone calls prove unfruitful, the hospital follows-up with an educational letter and an invitation to use the phone-number provider to reschedule the missed appointments. There is currently no good way of tracking when letters need to be sent out, or verify that they have gone out.

The initial evaluation and treatment sessions can be held at the hospital's central location, or, at the patient's option, at any one of the satellite service locations that the patient may deem more convenient because closer to work, school, or home. So the scheduler tries to give the patient's caretakers several choices of location, day of week, and time of day options from among the open evaluation slots made the scheduler knows about.

The problem at this stage, is, in practice, it is not easy for the scheduler to identify all the available initial evaluation and treatment slots. Although at this stage the scheduler is fully informed about the patient's preferences, the scheduler operates with
imperfect knowledge of the availability of the therapists, and particularly so when the therapists are based at a satellite facility.

4.5 The 65% Time Billable Time Rule

Instead of using the reporting functionality of a commercial therapist software scheduling module, the department generates weekly therapist billable time reports from its billing software, and collects information provided by the individual therapists of their own availability. There is a house rule that 65% of the therapist's hours available for work in any given week must be billable. The majority of the therapists are available for work Monday-Friday from 8-5 p.m., or 40 hours each week, after allowing for an hour off for lunch each day. In the case of a full-time therapist then, the 65% rule means that the therapist must bill at least 26 hours per week. The 65% rule also applies however to part-time therapists who work pro-rated work-weeks. In either case, full-time or part-time, there is no distinction is made between hours billed for evaluation sessions, and hours billed for treatment sessions, despite the fact that evaluation sessions are billable at a higher rate because they require time to conduct upfront research about the patient, and then also more extensive reporting than the more ordinary treatment sessions.

The balance of the therapist's work-time beyond 65% is intended as unstructured time to be used for paperwork and report writing, case research, personnel meetings, phone calls with physicians, parents, and staff, and other administrative items.

The 65% billable time target is tracked by means of the billable hour session submissions made through the department's billing software. The therapists are free to
record a billable session immediately after hosting a face-to-face session with the patient, or at the end of every day or work-week.

Following industry practice, only face-to-face OT/PT sessions with the patient conducted on site for a medical purpose are billable. The sessions are billed at pre-determined hourly rates, in increments of 15 minutes, called a unit. There can be considerable variation on the actual dollar amounts charged for the same type of event or medical condition. The rates are set based on contractual volume discount arrangements with insurers, benchmark parameters set by government re-imbursement programs, and sliding fee scale arrangements with patients. Because of the additional man-hours associated with the writing of an evaluation report requirements, the billable rates for evaluation and treatment sessions are different. The billable rate for an evaluation session is significantly higher than the billable rate for a treatment session. Time spent on the phone or in the lobby with a physician, a patient, or a patient's care-taker, is however not billable. Time spent helping to schedule or educate patients and their families is also not billable. Only face-time medical therapy, with the child face-to-face with the patient, is billable time.

The software used to report billable time is specialized, and integrated with the hospital's patient care and payment and re-imbursement software. The therapist utilization rates are summarized in reports generated by this software. The reports are reviewed by the therapist's immediate supervisors before being forwarded internally.
4.6 No Scheduling Software

The OT/PT department uses the hospital's main patient tracking software for general purposes, including billing. It also uses a specialized software package with document templatizing capabilities to generate individualized, but still fairly structured, patient evaluation and progress reports. There is also a third software package that is used to track the therapist's billable hours. However, the department has opted not to license a therapist scheduling software module.

Several items factored into the decision not to license the therapist scheduling module. The first reason was the desire to avoid software training on too many different complex software packages, and incidentally avoid some duplicate data entry, which could give rise to errors and inconsistencies, the bane of parallel software systems. A second reason was that an initial version of the software had been developed in house over the years, and then licensed to a third party against free use and an expected royalty stream from the marketing of the software elsewhere. The third party made changes to the software over time, and used the department to help perfect its functionality. Then instead of paying royalties, the third-party turned around and strong-armed the department into licensing an enhanced version of its own software, at a considerable cost to the department. In the face of these unanticipated costs, budget limitations made the additional cost of also licensing the scheduling module prohibitive.

A third reason not to license the therapist scheduling module was the desire in-house to respect the scheduling preferences of the therapist. The department also sought to protect the therapist's sense of independence, and so help morale and reduce staff
turnover, important considerations when dealing with highly trained and well-compensated professionals in a field in which attracting and retaining qualified personnel can be difficult and expensive.

The initial driving belief to offer so much scheduling latitude to the individual therapists appears to have been that the therapist has the best and most up-to-date knowledge of their patient's medical needs, on account of their frequent personal contact with the patient, and the patient's care-givers. With this knowledge in hand, even if a patient was initially scheduled to a series of, for example, six weekly treatment sessions, it should be up to the therapist from week to week to decide whether another treatment session next week is warranted or not. The therapists were not comfortable with the notion that, if the scheduler were to control the therapist's appointment schedule, there was a potential conflict in that, once seeing the appointment block of six reserved appointment slots coming to an end, a scheduler could book another patient for what would have been the seventh session, and thereby pre-empt the therapist's discretion to host a seventh session with the patient in their usual time slot, even though only six sessions had been planned initially.

Another important consideration was the fear of becoming overworked by being assigned a disproportionate amount of appointments compared to other therapists. The fair workload balancing requirements and the disadvantage of slot pre-emption is what seeded the idea to replace the current approach with the novel week-over-week forward scheduling algorithm introduced in this paper. This new algorithm eliminates the need to administer an appointment block back-log, and so provides added flexibility in extending
and cutting short appointment series blocks as needed. Importantly, it also preserves the therapist's discretion to extend our curtail a patient's appointments as needed.

The absence of a scheduling software has important implications for the daily functioning of the OT/PT division. The next several sections detail some of them.

4.6.1 Individual Appointment Books

Each of the 120 therapists maintains an individual, personal book of appointments. Some therapists use an electronic spreadsheet. Others use a hand-written, bound paper notebook, or an appointment booklet with a built-in calendar. As the week progresses, each therapist updates their book of appointments with information about the treatment and evaluations sessions they have hosted face-to-face with a patient. They also receive information about cancellations and new evaluation requests, mostly via eMail generated by the schedulers and receptionists, at times with short notice, if not entirely after the fact.

At the end of every week, after reviewing the entries in their personal appointment book, each therapist files a required but informal and un-structured forward-looking report with their local supervisors on their prospective availability during the next two weeks.

The individual therapists use multiple means to send this weekly information to their supervisors, including faxes, emails, phone and hallway conversations, spreadsheets and hand-written notes. Larger locations circulate a sign-up sheet, in which each therapist enters and initials their upcoming availability for new evaluation and treatment
appointments. For smaller locations, the designated scheduling supervisor for that location may fill out the entire sign-up sheet based on information they recall or received informally from their therapists.

There is one therapist supervisor assigned to every satellite service location. At smaller satellite facilities, this supervisor may not be on site, and may have overlapping duties with a second and third satellite service site. The two larger locations have more than one supervisor on site, one for OTs, another for PTs. Once the location supervisor has been able to coax the weekly submissions out of the therapists, she then forwards the weekly sign-up sheets as a package to the scheduling supervisor at the hospital's main location. The scheduling supervisor at the hospital’s main location in turn on receipt in turn then makes the information available to the schedulers.

4.6.2 Three-Ring Binders

When the therapist availability information package is received from the scheduling supervisor every week, it is simply hole-punched and added to a set of three ring binders. As additional information from late submissions is added, and updated information becomes available as the week progresses, the three-ring binders are updated with annotations entered by hand, in an ad-hoc fashion. The three-ring binders have tabs that list therapists by location and OT or PT designation, but not by therapist sub-specialty. There is no information in the binders on how to contact the therapists.

No attempt is made to post the weekly availability information collected from the therapists into a calendaring application or electronic spreadsheet. With 125 therapists on
staff at 9 locations, he transcription into an electronic medium is seen as burdensome and error-prone. An electronic version is also regarded as un-helpful because it would be difficult or slow to access, particularly when the scheduler is trying to schedule an appointment over the phone from home, sometimes during the evening and weekends. In fact, apparently to make sure all the latest hand-written update information is properly recorded in one place, there is only one set of binders. However, the single set also means that when attempting to schedule a patient, the schedulers must share the three-ring binders over the tops of their cubes.

There are three elements which make it difficult to extract meaningful scheduling information out of the entries in the three-ring binders. The first one is that the entries are not made in calendar fashion, but rather in the form of a signup sheet, one line per therapist. The entries also differentiate between appointment slots the therapist is choosing to make available for treatment sessions, and, separately, the appointment slots the therapist chooses to make available for the more protracted evaluation sessions. In the end, the entries by the name of each therapist read cryptically something like this: "same as last week," "treat wed 4-5 eow n/ 5 weeks," and "T,T 2-3 eval." In the first case, who has last week's binder? In the second case, the therapist is saying that they have a block of 5 treatment slots available beginning next week, on Wednesdays from 4-5 pm, for the next 5 weeks. The third case says that the therapist has two evaluation slots available next week, on Tuesday and Thursday at 2 p.m.

When talking to a patient over the phone, the scheduler has to quickly translate these cryptic entries in the three-ring binders into more meaningful calendar dates. For example, following an evaluation, a therapist may tentatively decide that the patient
would benefit from a block of therapy sessions, once a week for 8 weeks. The house and
patient preference in most cases is to use the same therapist for both the initial evaluation
and any subsequent treatment sessions. However, if the therapist who hosted the
evaluation cannot accommodate the patient for the follow-up treatment sessions, or the
patient want to change locations, the scheduler must find a therapist of the appropriate
OT or PT designation and sub-specialty who does. Appointments scheduled under these
circumstances can be problematic. Even if he scheduler can find a suitable therapist, by
midweek, unless another scheduler has added a comment to the three-ring binder, the
scheduler will not know, and must remember to ask, if another scheduler has already
claimed any or part of the available elements with a given block of appointments, but did
not cross-off the entry to show that they did.

4.6.3 Eval vs. Treat Binder Entries

The three example signup sheet entries above show that the therapists are very
careful to differentiate the appointment slots they are willing to make available for
treatment sessions from the slots they have available for the evaluation sessions needed
by new patient referrals. The slots intended by the therapist to be used for evaluation
sessions are deliberately reported and treated separately from the ones they chose to
designate as being available for treatment sessions.

The differentiation between slots available for evaluations and slots available for
treatments is very important in the eyes of the therapists because of the additional setup
research, reporting, secondary paperwork, and physician contact associated with an initial
evaluation when compared to an ordinary treatment session. The additional effort can be time-consuming, an additional three or four man-hours beyond the billable face-time allowed for each session.

The intent behind the differentiation between evaluation and treatment slots seeks to shield the therapist from over-booking, and at the same time make some allowance so that new referrals can added to the pipeline as quickly as possible.

In the current hospital's approach to therapist scheduling, it is left up to the therapist to decide how many open evaluation and treatment slots to make available every week. The therapist is expected to do so by looking at their own personal schedule of appointments, and from that view estimating their hourly workload for the coming week. The therapist is free to designate the specific weekdays and timeslots when to offer their evaluation and treatment session openings. The therapist's only constraint is being accountable for meeting the 65% billable time rule, the administrative control used to measure therapist productivity. Should the therapist make too many slots available, and, in particular, too many evaluation slots available, they risk over-booking themselves for the week. At the same time, if they do not make enough time-slots available for bookings, and in additional underestimate their cancellations for the week, they risk not meeting the 65% percent billable time rule.

Clearly then, the flexibility built-in to the differentiation of eval appointment slots from treatment appointment slots seeks to both to better serve the need for immediacy on the side of the patient, and take advantage of the higher billable rate of an evaluation over the lower billable rate associated with a treatment session.
Unfortunately, as the new scheduling model implemented in this study shows, the therapists tend to under-estimate and under-report their availability for evaluation sessions. In addition, by designating and so limiting in advance which weekday timeslots they choose to make available for evaluations and treatments, the therapists also fail to take into account the individual appointment preferences and limitations of the patient.

The result is to make it more difficult for the scheduler to find a suitable match between patient and therapist, one that properly balances the workload edicts and availability preferences of the therapist against the personal needs and scheduling preferences of the patient.

In the end, because of the differentiation between sessions intended for evaluations and treatments, a scheduler almost never uses an available evaluation slot to book a treatment session for a patient. The one-of nature of the evaluation session would in any case pose a problem for the therapist, should the therapist decide at the end of the patient's visit that the patient needs a follow-up session the following week. By midweek, after the therapist has hosted the patient's treatment session and made a decision, this next session could have been booked for someone else already.

Conversely, on the use of treatment slots as evaluation slots, the house rule is that a scheduler is free to use an available treatment slot for an evaluation slot only if the treatment slot in question has not been booked for a treatment 72 hours in advance of its expiration. The approach serves the dual-purpose of making it possible in principle to schedule an evaluation from a new referral on short notice, and at the same time, given that the likelihood of the slot actually being called to use this way is quite low, also allay
the therapist's fears that they will be over-booked with evaluations, and so over-worked for the week.

4.6.4 No Holiday, Earlier Booking, Or Day Off Tracking

The entries also do not make any allowance for holidays, or earlier bookings by other therapists, or therapist part-time status, vacation days or personal days off. The schedulers cannot determine if the Monday two weeks out requested by the patient is a school or federal holiday, and so must either know that already, or consult a separate calendar. Unless the earlier scheduler has added a note, any available slots claimed earlier will still be shown as available, thus inviting a conflicting double-booking. And there is no formal mechanism to alert the scheduler about therapist absences, off-shift employment arrangements, or part-time status.

4.6.5 No Unused Appointment Recycling

Last minute cancellations and no-shows cannot be recycled back into the therapist's appointment availability pool because this daily information is not captured in the three-ring binders, which are only updated weekly. At other times, when the therapists may have taken the binders home, or only specific pages, to phone patients during the evening and weekends, the binder may not be readily accessible the next morning to accept an updated entry until the scheduler comes in for an offset shift. Any
stray pages also have to be put back in. Worse, the earlier arriving scheduler has to wait until their colleague arrives later on Monday morning to begin their scheduling efforts.

4.6.6 No Therapist Skillset Info

Although each OT and PT therapist is licensed for the full range of medical conditions within their designation as an OT or PT, in practice they tend to specialize in roughly 20-25 sub-specialties within their own discipline. The sub-specialty preferences may develop either by reason of the therapist's own personal preferences, their seniority and level of experience, or because they and their supervisors are seeking to better serve or cover a given targeted population of patients. In this work the combination of the therapists OT or PT licensed designation and these sub-specialties are referred to as the therapist's skillset.

For example, a therapist may choose to work preferentially with patients under the age of two, or with patients with brain injuries. To the schedule, this means that they have to identify not only a therapist with the appropriate OT or PT designation, but also at the same time a therapist of that designation who has an evaluation or treatment slot available that matches the patient's location, calendar day, day of week, and time of day scheduling preferences.

The therapist's sub-specialty information is currently not tracked by any software. Rather, it is shared and discovered informally by discussions between the referral slip evaluation specialist, the schedulers among themselves, and the therapists. This
information is not always easily obtainable, because the schedulers work from the main location, and the therapists could be at any one of 9 different satellite locations.

4.6.7 No Tracking Of Caretaker Preferences And Changes

There is no software to track changes to the patient's appointment preferences, or an electronic means for the patient to check their own schedules from home over the internet, or make requests for appointment changes or cancellations. Any changes about vacation days, cancellations, and no shows must be phoned-in.

In practice, it appears at least 20-25% of all appointments, initial evaluations and treatments, are never held as originally scheduled, because of last minute cancellations or no-shows on the part of the patient. About 50% of the 30-40 patient referrals are never held, much to the chagrin of the departmental staff, which will have in the preceding weeks have invested a good number of man-hours in the processing of the initial referral, including physician queries, insurance validation, and patient contact seeking to set an appointment.

Therapist vacation or personal days off due to illness or personal issues also contribute to the percentage of cancelled and re-scheduled appointments, but on a smaller scale. To help keep the schedule simple, the department more often than not simply skips appointments held on holidays or vacation days, rather than to try to re-schedule them for the same week.
The high-rate of no-shows, cancellations, and re-schedules pose more than just a logistical problem for the department. The department can only bill for an actual face-to-face medical consultation with a therapist, and not for any preparatory work. Last-minute cancellations and no-shows are not billable, and so create a hole in the therapist's billable ratios. In practice, the therapist re-directs their efforts during that hour to clearing their reporting back-log, and some therapists have come to rely on a given percentage of cancellations to get all of their paperwork work done.

Currently, the department tries to reduce the number of last-minute cancellations and no-shows only after the fact, with follow-up phone-calls and form letters that gently remind the patient and their care-givers to honor their appointments. The department in years past more than once attempted to host patient education nights as a first step in the initial OT/PT evaluation and treatment scheduling cycle, at time in conjunction with parent support group sessions. The effort sought to provide better overall patient and parent care, and thereby hopefully decrease the percentage of cancellations, no-shows, and re-schedule requests. However, the department has all but has discontinued the practice as a concerted effort. Important constraints have been that the parent-based leadership and membership of the support groups change rapidly, that it proved difficult to agree on a location rotation for the education sessions that would be agreeable to all, and that educational sessions, unlike medical sessions, are not billable or re-imbursable.
4.7 AS IS OT/PT Patient Scheduling Workflow

Figure 10 summarizes the AS IS OT/PT patient appointment scheduling workflow for the OT/PT facility in the case study. Note in Figure 10 that the caregiver billing process informs the current scheduling process, and that the reporting process is based entirely on information from the billing process (65\% rule). The information from the referral, scheduling, and caregiver slot drop processes is hidden and so lost to the reporting function.

Figure 10 also shows that the AS IS OT/PT patient workflow consists of the following processes: the referral workview (Figure 11), the scheduling workview (Figure 12), the billing workview (Figure 13), and the administrative reporting workview (Figure 14). Each of these is briefly discussed in the next few sections.

4.7.1 AS IS Referral Processing Workview

Figure 11 shows the current patient referral processing workview. The referral process is an early bottleneck in the current AS IS OT/PT patient scheduling workflow. Every referral is manually reviewed by one of the two or three in-house referral specialists, in the same way a physician's prescription is filled by a licensed pharmacist. The purpose of the review is to decide if the patient's case is to review the primary diagnosis and the secondary presentations to decide if the patient's case would be better served by an OT or a PT therapist. In some cases, the assignment may be to both an OT and a PT therapist. Alternatively the referral specialist may decide the patient's case is
Figure 10. The AS IS OT/PT outpatient scheduling workflow. The referral, scheduling, billing, and reporting workviews are detailed in Figures 11-14. The therapist evaluation and treatment slot drops are explained in the text.
Figure 11. The AS IS patient referral processing workview. Legend: (1) Did the physician sign and date the referral slip? (2) Can ID the physician? (3) Is there enough information to interpret the referral slip? (4) Contact the physician; (5) Contact the payor; (6) Contact the patient; (7) Interpret the referral ("assign a preliminary primary diagnosis"); (8) Forward the patient case to the scheduler with the instruction to assign the case to a therapist with an OT skillset, one with a PT skillset, separately to both an OT and a PT, or neither ("by looking at the primary diagnosis and secondary presentations")?
Figure 12. The therapist-centered, manual AS IS OT/PT patient scheduling workview. Legend: (1) Initiate an OT or PT evaluation appointment request; (2) Initiate an OT/PT treatment appointment request; (3) Notify scheduler; (4) Has payor authorization been received? (5) Attempt another authorization? (6) Is there a match between the caretaker's appointment preferences and a therapist open slot? (7) Has a week elapsed? (8) Book the appointment; (9) Did the patient show up for their scheduled appointment? (10) Is it the second time the patient did not show up? (11) Send educational letter with phone number to call to reschedule; (12) Did the patient's caretaker call to reschedule?
Figure 13. The AS IS billing workview. Legend: (1) Was it an evaluation? (2) Record and bill as an evaluation; (3) Was it a treatment? (4) Record and bill as a treatment; (5) Does the patient need another set of treatment sessions? (6) Is the therapist able to book the treatment sessions for herself?
Figure 14. The AS IS administrative reporting workview. Legend: (1) Generate billable time report for the week; (2) Determine therapist's hours available for work that week; (3) Calculate the and review 65% billable time metric in a spreadsheet.
more properly handled elsewhere, for example by a speech therapist. The problem is that there is that the manual process currently makes no provisions for learning storage and memory recall of previous OT/PT therapist assignments with a similar primary diagnosis and secondary presentation profile. Without learning storage and memory recall, the OT/PT assignment know-how is retained entirely in the head of the referral specialists, and the referral step cannot be expedited.

4.7.2 AS IS OT/PT Patient Scheduling Workview

Figure 12 shows the AS IS OT/PT outpatient scheduling process that takes place after the patient's referral has been processed by the referral specialist. Figure 12 shows that the scheduler first considers whether or not there is payor clearance for the scheduling of an appointment with the patient (step 4), instead of scheduling the patient's appointment first, and letting the payment issue resolve itself later. Figure 12 also shows that the therapist evaluation and treatment slot drops are an additional process stranglehold. As detailed earlier, currently, every week each therapist at every location files a report in which they list the appointment slots they are willing to make available for evaluations, and separately, for treatment sessions. The therapists also specify the frequency (weekly, ever other week) and duration (how many weeks) they are willing to make a particular slot available. The drop is forwarded through the supervisory and location tree, and eventually consolidated in three-ring binders for manual access and review by the human schedulers. The weekly evaluation and treatment slot drop practice has its roots in the standing house practice of having each therapist maintain their own
personal book of appointments. It makes it extremely difficult for the human scheduler to establish what slots are available where, and for what, and for what periods. The human scheduler also does not have access to the details of therapist's skillset, and so cannot offer multiple appointment that are aligned with the patient caretakers' weekday, time, and location preferences.

4.7.3 AS IS OT/PT Patient Billing Workview

Figure 13 shows the AS IS billing process workview. At the end of every OT/PT therapy session, upon returning to their desks, the therapists update their SOAP notes and record the fact that the session was held and so is billable into a specialized billing software. Because the billable rate is different for evaluations and treatments, the therapist also flags the entry as having been an evaluation or treatment session. The software tracks the therapist's billable time for the week and month.

4.7.4 AS IS OT/PT Patient Reporting Workview

Figure 14 shows the AS IS administrative reporting process. The only productivity control metric is the occasional review of spreadsheet prepared by hand which shows the ratio of therapist billable hours for the week to the hours they made available for work that week. The software used by the therapist to report on their billable time for the week generates a billable time report. However this software does not necessarily have up-to-date knowledge of the hours the therapist actually made
available. The administrator has to manually incorporate this information into the spreadsheets from rules of thumb, based on the therapist's full or part time hire status, or from clerical input following a query to each therapist on the issue, before calculating the 65% billable time control metric.

4.8 TO BE OT/PT Patient Scheduling Transformation

The current AS IS OT/PT patient scheduling workflow has several knots and entanglements. Almost half of new patient referrals currently end up not sitting for an OT/PT evaluation, but the hospital may nonetheless spend an entire month early on establishing the eligibility of a prospective OT/PT patient for third-party re-imbursement and obtaining pre-authorization for OT/PT services. The assignment of a new patient evaluation to an OT or PT therapist is constrained by the know-how in the head of the referral specialist. Therapists maintain their own book of appointments, and on a weekly basis publish the open appointment slots they choose to make available for scheduling based on billable time considerations. For every appointment, the schedulers undertake an ad hoc discovery of therapist skillsets by location and of caretaker appointment scheduling preferences by location, weekday, and daytime.

Figure 15(a) summarizes the AS IS OT/PT patient careflow. Figure 15(a) shows that the AS IS OT/PT appointment workflow prioritizes administrative billable time and payment questions, protects the work-hour welfare of the therapists, and preserves the know-how of the referral specialist. There are no mechanisms in place to capture the caretaker appointment preferences, or even the OT/PT therapist distribution and skillset
mix by location. The human schedulers are asked to book OT/PT patient appointments by supplying information they do not know because they do not own it. What they learn is not captured for subsequent re-use. Patient medical needs are served last.

Figure 15(b) summarizes the TO BE OT/PT patient careflow. All actions are subsumed to the medical needs of the patient, and payment issues are resolved last. The new OT/PT scheduling uses Separation of Duties dis-entangles the workviews of the referral specialist, caretaker, therapists, schedulers and payors. In each case, owned knowledge is captured and shared for re-use by others. The schedulers are no longer asked to book an appointment by piecing together information that is not easy for them to obtain. The actual scheduling of the OT/PT patient population is automated with the prioritized queues and intelligent routing described in Chapter 3.

The next chapter, Chapter 5, provides an example implementation of the new OT/PT scheduling system within the context of the patient careflow in Figure 15(b).
Figure 15. Generalized (a) AS IS and (b) TO BE OT/PT patient careflow
Chapter 5 - Model Application And Implementation

This chapter begins by outlining the steps taken for the operationalization in software of the new OT/PT patient scheduling system developed in Chapter 3, and its implementation within the context of the case study described in Chapter 4. It then briefly discusses each TO BE workview, and presents the results obtained by simulation for selected scheduling scenarios. The chapter closes with a set of operational, tactical, and strategic recommendations intended to facilitate the implementation of the new OT/PT scheduling system in practical environments, such as the one encountered in the case study.

5.1 Model Operationalization

To operationalize the generalized TO BE patient cycle of care in Figure 15(b) in a way suitable for the population-level automation of OT/PT patient scheduling, the AS IS workflow from the case study in Chapter 4 (Figure 10) was converted to the TO BE workflow shown in Figure 16.

The AS IS workviews (Figure 11 through Figure 14) were also converted by Separation Of Duties to the corresponding the TO BE workviews shown in Figure 17 through Figure 22.
**Figure 16.** The TO BE OT/PT patient scheduling workflow, abstracted under Separation Of Duties. OT/PT appointment scheduling (Figure 8(a)) is automated and scaled at the population-level. Report generation (Figure 8(b)) requires no data input from operators. Each of the abstracted functions in the figure is executed with input from independent roles: referral specialist: Figure 8(c); caretaker: Figure 8(d); caregiver: Figure 8(e) and Figure 8(f). Contrast with the AS IS OT/PT patient scheduling workflow in Figure 10, and the associated abstracted workviews in Figure 7(a) and Figure 7(b).
Figure 17. The recommender-assisted TO BE patient referral processing workview. The recommender has built-in memory recall, know-how capture, and learning capabilities. Legend: (1)-(6) as in Figure 2; (7) Can the database history make an OT or PT skillset recommendation? (8) Make intelligent database OT/PT skillset recommendation; (9) Interpret the referral (i.e. assign a preliminary primary diagnosis code) and flag the patient as needing the services of either an OT-skillset therapist, a PT-skillset therapist, or (infrequently) separately to both an OT and a PT, or neither.
Figure 18. The caretaker's TO BE appointment preferences capture workview. **Legend:**
(1) Do you want to make a new appointment or change an existing one? (2) Let the caretaker pick a weekday, time and location from a calendar; (3) Is there a late change fee? (4) Charge a change fee; (5) Do you want to enter a specific appointment date or a preference? (6) Capture the caretaker's appointment preference; (7) Do you have additional location, weekday, daytime, or timing preferences?
Figure 19. The therapist's TO BE decision processing workview. Legend: (1) Do you want to dispose of an appointment for a patient you saw today, or report on when you will take a vacation day or other personal day off? (2) Capture the therapist's rollover decision (and so the billing status) for the appointment in question; (3) Capture the caregiver's forthcoming personal vacations and days off.
Figure 20. The automated TO BE OT/PT patient appointment scheduling workview, a computerized implementation of the new OT/PT patient scheduling system in Figure 3. For legend, see text. The therapist decision process is shown in Figure 19. The booking and backlog sub-processes implement the details of the intelligent OT/PT appointment request routing and OT/PT appointment booking behavior of Figure 6(1)-6(5).
Figure 21. The TO BE billing workview. Legend: (1) Was the OT/PT session held? (2) Was the OT/PT session based on a physician referral? (3) Was the OT/PT session based on a caregiver's determination of need and benefit? (4) Was the OT/PT session welcomed by the patient as consistent with the patient's values? (5) Is a third-party payor going to pay for the service (6) Can the third party's payment denial be contested? (7) Are there alternate means of payment? (8) Bill for the OT/PT session.
**Figure 22.** The TO BE OT/PT administrative reporting workview. *Legend:* (1) Review and act on one of the many reports in Appendix C.
Software simulations for various OT/PT scheduling scenarios were then run to investigate the theoretical functionality of the generalized workflow shown in Figure 15(b).

5.2 Software Implementation

The TO BE OT/PT outpatient scheduling workview of Figure 20 was implemented in software. The workview of Figure 20 uses the new OT/PT scheduling system shown earlier in Figure 3 of Chapter 3. It automates the AS IS role of the human OT/PT patient scheduler shown in abstracted form in Figure 7(a) and in workview form in Figure 12.

The appointment booking and appointment backlog processes in Figure 20 used randomizers to (a) simulate new referral arrivals, evaluation and treatment appointment requests; (b) mimic successful and un-successful appointment outcomes and follow-up bookings; (c) initiate appointment re-schedule requests following holidays, cancellations and no-shows; (d) emulate the inputs anticipated to be supplied by the referral specialist (Figure 8(c)), the caretaker (Figure 8(d)), and the therapist (Figure 8(e) and Figure 8(f)); (e) match patient medical needs to therapist skillsets, and caretaker preferences to available slots; (f) drive the program execution so that it would abide by workload-balancing and continuity of care considerations; and (g) generate the reports in Figure 8(b) and Appendix C.
5.3 TO BE OT/PT Patient Scheduling Workflow

Figure 16 shows the automated, population-scalable TO BE OT/PT patient scheduling workflow. In contrast to the AS IS workflow of Figure 10, the TO BE workflow of Figure 16 shows an OT/PT patient referral that is recommender-assisted, and independent scheduling and billing processes. The therapist slot-drop information flow strangle-hold of Figure 10 has been removed in Figure 16 in favor of the routing of evaluations and treatment appointment requests through intelligent queues and the selection of workload-aware automated appointment bookings. Unlike Figure 10, the reporting function in Figure 16 can report on all processes.

5.3.1 TO BE Patient Referral Workview

Figure 17 shows the recommender-assisted TO BE patient referral workview. The recommender is automated. It helps remove an important barrier to OT/PT patient scheduling, the assignment of the patient case to a therapist specializing in either OT or PT (or both or neither). The recommender has built-in know-how memory recall and learning capabilities. Data copied from the current patient's referral slip can be used to automatically make an intelligent OT/PT assignment recommendation based on earlier similarly situated patient referrals, those having an equivalent primary diagnosis and secondary presentation profiles. When the referral specialist validates or changes the OT/PT assignment recommendation, the automated recommender captures and learns
from this know-how, and so can make a better automated OT or PT assignment recommendation the next time it is activated. With the OT/PT decision made, the scheduler can then select the specific therapist needed by taking into account the caretaker's scheduling preferences, as well as the therapist's current workload.

5.3.2 TO BE OT/PT Patient Caretaker Workview

Figure 18 shows the workview designed to support the capture of the caretaker's appointment scheduling preferences. The information that must be captured from the patient's caretaker is the set consisting of preferred location, weekday and daytime limitations, earliest acceptable start date, and the timing in number of days in the case of delays before accepting an appointment at the hospital's main location instead of at their preferred location. The capture of this information eliminates much of the information discontinuity in the OT/PT appointment scheduling workviews of Figure 7(a) and Figure 12, as well as the need for constant phone call interruptions and phone-tag call-backs. The capture process is made possible by a web-enabled input and update interface accessible through a secure connection from home, work, or school, or from a kiosk in the lobby of the hospital's OT/PT Welcome Center. Once captured, the information can be reused when scheduling the next set of OT/PT appointments for the patient. To support the caretakers who prefer a phone tree approach, the same interface is available to the patient facilitator in the Welcome Center. The caretaker uses the interface to report on their preferences for OT/PT appointment weekday, time, location, start date, and turnover date between main location and preferred location. The caretaker can also use
the interface to review the patient's appointment schedule, and report on the need to reschedule an appointment, possibly against the collection of a small re-schedule fee.
Mashups in which additional information that is important and attractive to the caretaker can also be added, for example the status of a wheelchair funding requisition, or a preferred-location community plug-in showing school events and soccer practice dates.

5.3.3 TO BE OT/PT Patient Therapist Workview

Figure 19 shows the therapist's TO BE decision workview. The workview lets the therapists report on their appointment rollover decision following an evaluation or treatment appointment hosted that day. Note the therapist need only request, but not schedule, a roll-over appointment for a given patient. It also presents a personal scheduling perspective which lets the therapists report on their future vacations and days off. The therapists need not account for their billable time, or open slots--the computer will do that for them. They need only report exceptions to the routine of their part-time or full-time workweek availability, whatever this routine may be. The computer will schedule the OT/PT patient appointment so as to (a) meet the patient's medical and continuity of care needs, (b) abide by the patient caretaker's appointment scheduling preferences with respect to location, weekday, daytime, and timing, and (c) distribute the patient caseload by fairly and equitably at among all therapists and skillsets at all locations while protecting the therapist from overwork with workload computations and avoiding conflicts with existing appointments.
5.3.4 TO BE OT/PT Patient Scheduling Workview

Figure 20 shows the automated TO BE scheduling process. The items 1-17 in the figure are:

(1) Randomize the treatments held during the scheduling cycle in question;
(2) Randomize the evaluations held during the scheduling cycle in question;
(3) Priority sort the treatment backlog request queue, longest wait first;
(4) Priority sort the evaluations backlog request queue, longest wait first;
(5) Add new referrals for the scheduling cycle in question to the evaluations backlog request queue;
(6) Randomize the evaluations backlog queue;
(7) Was the OT/PT appointment held as scheduled?
(8) Flag the appointment as billable;
(9) Reset the no-show count to 0;
(10) Flag the appointment as not billable;
(11) Increment the no-show / cancellation count;
(12) Has the no-show / cancellation count limit been exceeded?
(13) Set the needs follow-up scheduling status flag to true or false;
(14) Is a follow up appointment needed?
(15) Mail educational materials and re-scheduling instructions to the patient's caretaker;
(16) Did the caretaker call back?
(17) Was the appointment successfully booked?
5.3.5 TO BE OT/PT Patient Billing Workview

Figure 21 shows the TO BE billing process. Unlike the AS IS billing process in Figure 13, which loops back into the AS IS OT/PT patient scheduling workview shown in Figure 12, the TO BE billing workview in Figure 21 is kept separate from the scheduling workview of Figure 20. As detailed later in Chapter 6, it is this separation that makes it possible for the workview in Figure 20 to serve as the foundation for eventually removing OT/PT patient scheduling from the hospital’s daily functioning, and instead implementing OT/PT payments through Electronic Statistical Area (ESA) brokerages.

5.3.6 TO BE OT/PT Patient Reporting Workview

Figure 22 shows the TO BE administrative reporting workview. The TO BE reporting process automatically generates more than 15 multi-dimensional productivity tracking and drivable control metrics, as listed in Appendix C, without requiring any manual data collection or operator data input.

5.4 Experimental Simulations

The experimental simulations were initially parameterized with the data obtained from the questionnaire in Appendix A. These initial simulations revealed that the workload of the therapists in the case study was very low. Subsequent runs increased the number of new patient referrals and the average number of follow-up treatment sessions
per hosted evaluation, and decreased the total number of therapists available for scheduling. The results of these simulations appear in summary form in Table 4 and Figure 23. Additional simulations sought to vary all of the configurable secondary scheduling parameters, and so exercise the new scheduling system through a reasonable number and a good mix of plausible OT/PT patient scheduling scenarios.

### 5.5 Experimental Findings

1. **The New Scheduling System Worked.** The new scheduling system did successfully produce a book of OT/PT appointments. The evaluations and treatment sessions were booked automatically after an initial patient referral was generated. The simulations identified the therapists having the skillset needed to meet the medical needs of the patient, and then booked evaluations and treatment sessions which met the scheduling preferences of the patient caretakers. The bookings were done by considering the current therapist workload for the week, and so fairly and equitably balancing the workload of all therapists at all locations for every scheduling cycle.

2. **The New Scheduling System Was Well Behaved.** Variations in key parameters produced predictable results suitable for optimization. The new scheduling system functioned well in the presence re-schedule requests originating from simulated holidays, no-shows and cancellations, treatment plans of varying duration, and random sets of caretaker appointment references. It advanced appointments through the calendar for the
Table 4. Case Study Simulation Results. This table presents the results of the simulations for Week 26, with initial parameters obtained for the case study as detailed in the questionnaire shown in Appendix A. At 26 weeks, with $m_e = 3$, $m_t = 1$, and 20% of appointments rescheduled due to cancellations and no-shows.

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Figure 23. Simulation results showing caretaker’s preferred location selectivity. The average number of treatments per hosted evaluation was increased to compare the man hour utilization at the main OT/PT service location and the satellite locations. As the patient case load increases, the new scheduling system retains its selectivity to preferentially schedule the patient at the caretaker’s preferred location.
entire length of the simulation, for every week one and two years out, until terminated. It generated detailed multi-dimensional reports automatically, without requiring any operator input.

The new scheduler ramped up smoothly starting from an empty book of appointments before reaching a steady-state equilibrium behavior. It degraded gracefully with longer appointment setting delays and larger numbers of backlogged evaluation and treatment requests as (a) the number of therapists deployed for a given new patient referral rate was decreased; (b) the ratio of therapists at the satellite locations to the main location was lowered; (c) the average number of treatment sessions per initial evaluation was increased; (d) the number of secondary skillsets per therapist was raised; (e) the percentage of no-shows and cancellations was set higher; and (f) the average of the random number of preferences a caretaker made available for booking was reduced.

5.6 Limitations And Enhancements

Every effort was made to ensure that model is sufficiently well defined and parameterized to serve as a baseline or reference point for more detailed or specialized adaptations that take reality details of greater granularity into account. Because designed with an intentionally extensible architecture, the new automated OT/PT patient scheduling system as currently implemented in software already invites funding for enhancements to some of the limitations imposed by the initial simplifications made to get the new OT/PT scheduling system running in an initial form in software.
Considered in this section are software enhancements related to (a) part-time therapists; (b) therapist vacations, illnesses and days off; (c) patient diagnosis biases; (d) workload maximizing/minimizing therapist selection; (e) non-greedy optimization; (f) daily, monthly and odd appointment frequencies; (g) ranking and (h) biasing the caretaker appointment preference selections; and finally (i) extending the facility hours. In each case, despite the variety of considerations, the abstraction and space translation principles of the automated OT/PT patient scheduling system proposed and demonstrated in this study remain unchanged.

(a) Part-Time Therapists. Although the software as implemented supports the assignment of individual sets of hours available for work to each individual therapist, in anticipation of being able to capture and use this detailed information at a future date after the therapist availability interface becomes available, to simplify comparisons when of the data analysis, all simulations in this study were run with the assumption that all therapists are full-time time employees. Accordingly, each therapist avatar was assigned a work-shift that matches the facility hours at the location to which they are attached, and the simulations as run only made allowances in the workload computations for facility-level holidays. This was appropriate for the case study examined because the most every therapist was a full-time employee on salary, and because the caretaker appointment preference requests were also assumed to be equally distributed across all facility hours. However, at other OT/PT practices, particularly smaller ones, it is not unusual to have large complements of part-time therapists who are only paid based on their billable time. The impact on the study on the conclusions presented is not believed to be great because
the outcome of an evenly distributed appointment request pattern over an evenly distributed therapist availability window should be similar to the outcomes obtained from a clustered caretaker request distribution and a clustered part-time therapist availability window, who presumably would only be called to work during peak appointment demand times. In any case, to cover this scenarios more closely, additional simulations could be run in which individual work shifts are assigned to each therapist.

(b) Therapist Vacations, Illnesses And Days Off. In similar fashion, it would also be nice to be able to explicitly flag individual therapist avatars as not being available for a given scheduling cycle because ill or on vacation. The program currently emulates this only indirectly, with the use of a parameter that allows a random number of appointment cancellations and no-shows, but which not does differentiate whether the appointment was no held because the patient or therapist did not show up. Although the vast majority of appointments are canceled because the patient does not show up, it is also true about 10% of the time that appointment sometimes have to be canceled because the therapist did not report to work due do a vacation, illness, or personal day off.

(c) Patient Diagnosis Bias. The distribution of both the preliminary patient medical diagnoses assigned to a patient avatar, and of medical sub-specialties within the OT/PT designation of the therapist avatar was randomly selected. The randomizer selected evenly distributed across all possible medical conditions. In practice there is a skewness in favor of some more common preliminary patient medical diagnoses. The actual distribution is demonstrably exponential (Ireys, Anderson, Han, et al., 1996). For
example, the hospital gets more referrals of school-age children with an initial diagnosis of ADD (Attention Deficit Disorder) than of infants with brain injury following oxygen deprivation at birth, and some therapists may choose to work exclusively with patients under the age of two. In theory, this medical sub-specialty distribution issue is not believed to be substantive because each therapist is licensed to address the full range of medical conditions within their OT/PT designation. Because there is some clustering in the range of therapist sub-specialties based on the therapist's career preferences, and these may be expected to track with skillset demand, there is some equalizing ratioing taking place, thus making the random medical diagnosis and random therapist skillset assignments more reasonable. In practice however, the simulations may still be over-representing the scheduling options of a patient with a rare medical condition. So the simulations could be perfected with a biased medical condition sampler, and a similarly biased therapist skillset sampler.

(d) **Workload Maximizing/Minimizing Therapist Selection.** When more than one therapist with equivalent offerings can meet a given scheduling request, the software currently picks one of the available therapists randomly. Workload maximizing and minimizing variations may also be appropriate, and so need further investigation. To this end, the software could be enhanced to pick the therapist with the lowest workload, or yet the busiest therapist as measured by their current workload. In the first case, the intent would be to balance the case load as evenly as possible across all therapists, an important consideration of fairness in smaller shops. In the second case to find the minimum
number of therapists needed to reasonably service a given referral frequency and patient evaluation and treatment caseload, an important logistical consideration in larger shops.

(e) **Non-Greedy Optimization.** The current implementation of the model makes single-pass, first found, first matched appointment selections. The selection is made in a random matter among seemingly equivalent options having the same continuity of care character. The approach does distribute the patient case load equitably. The set of selections in the aggregate is however not necessarily an optimized one when measured for example in terms of the absolute shortest average wait times before an appointment is booked, or the absolute minimum number of therapists needed to service the entire patient case load. Another improvement to the program would be to repeat the weekly scheduling cycle multiple times with the same event randomizer outcomes, for example, whether or not the appointment was a no-show, but with different sets of random weekday and time of day picks. Then pick the one outcome from among the repetitions exhibiting the best result for a metric of choice. For example, pick the outcome with the greatest percentage fill of treatment re-schedules, the earliest average evaluation date or average first treatment appointment date, the greatest percentage of backlogged evaluation and treatment appointments flushed out of their wait queues, or the most evenly distributed therapist workload. These secondary optimizations would be fairly simple to implement, but would also require more memory and computational power in the way of a multi-processor machine, and the implementation of more sophisticated solution space search algorithms, such as swarm techniques.
(f) Daily, Monthly And Odd Appointment Frequencies. To keep the data analysis of the demonstration implementation simple, the scheduler simulations were run so as to schedule one appointment patient per week, or one appointment every other week, and the scheduling effort only attempted at the end of every week. The spacing of appointments over time is important because of the chronic nature of the condition, requires support over time, and patient and care-taker education, and practice and exercise at home. The program could easily be enhanced to support additional scheduling frequencies, for example monthly and four-or-five-day a week treatment appointment series regimens also used by the hospital, depending on individual patient needs, simply by allowing for more appointment frequency state flag variations beyond weekly and every-other-week. The enhancement would enable an automated daily run to search for and schedule just the daily, odd, or monthly appointment frequencies.

(g) Rank Caretaker Appointment Preferences. Another welcome enhancement to the software would be to let patients rank their appointment preferences at the time they make them known, and then try to optimize the schedule so that the greatest percentage of patients are assigned to their first or second preferences, as opposed to randomly to any of the appointment preferences made available by the patient's caretakers as the program now does. Currently, the patient avatar, by means of a randomizer, is permitted to report multiple appointment slot preferences, but not rank them. The greater the number of preferences the patient reports, the greater are the patient's chances of getting an appointment sooner. However, with the current version of the program, to the extent
that the patient had a greater preference for one or the other of their preferences, the less likely proportionately they are also to be assigned their first or second preference.

(h) *Bias Caretaker Preferences*. The simulation as implemented makes appointment request timeslot selections with equal probability for all timeslots and weekdays, Monday-Friday. The staff in the case study believe that the caretaker appointment preferences are biased rather than evenly distributed over all days and timeslots. For example, they believe the patient caretakers tend to make more requests for the middle part of the week, and on or after 3 p.m. There was however no data available to factually verify the extent of this bias. It would require a survey, or the tracking of the initial caretaker requests, as opposed to the weekday and time history of the appointments actually booked. Until a survey can be run or there is a software interface to collect and store the patient's preferences, the simulator could be enhanced to bias the caretaker selections in favor of middle-of-week and late afternoon appointments.

(i) *Extended And Weekend Hours*. The hospital does not currently offer OT/PT appointments after 5 pm, or on Saturdays and Sundays. It is anticipated that with increased scheduling automation, extended hours of operation will become more attractive, and the hospital will be able to distributed its fixed overhead over a wider appointment base. The software was implemented in anticipation of the need to support 7-day-a-week, 24-hour a day scheduling, but the simulations were run so as to cover only Monday through Friday, 8 am to 5 pm. Additional simulations could be run which vary the appointment options, for example, with offset shifts with appointments available
beginning only at 10 am, and extending them until 8 pm, or blocking off all Monday appointments in favor of introducing Saturday appointments.

5.7 Conclusions From Case Study

The application of the new OT/PT patient scheduling system developed earlier in Chapter 3 to the case study described in Chapter 4, and the findings of the simulations conducted in this chapter, have helped identify the operational, tactical, and strategic opportunities identified in this section.

It is anticipated that the consideration and adoption of the opportunities listed in this section will provide several benefits. Some examples: (a) streamline the current patient referral process, and make it possible to more easily identify therapist skillsets and billable utilizations by location; (b) help provide a clearer definition of "hours available for work," and more fairly and equitably balance the OT/PT patient caseload across all therapists at all locations; (c) address the needs for greater scheduling flexibility sought by part-time therapists, closer attention to scheduling preferences of the patient's caretakers, and higher quality of care delivery to the patient, with fewer no-shows, cancellations, re-schedules and delays.

The opportunities in this section also lay a path for the adoption of (d) the TO BE workviews under separation of duties, (e) the computerized balancing of the caretaker preferences and the therapist workload advanced in this study, and (f) the eventual outsourcing of OT/PT patient scheduling and the implementation of ESA-brokered OT/PT services anticipated in Chapter 6.
5.7.1 Operational Opportunities

1. *Discontinue The Practice of Having The Therapists Report Their Own Availability.* The current OT/PT patient scheduling worldview is therapist-centered. The OT/PT must instead be refocused to be patient-centered, an enable the schedulers to function in a way that is responsive to the scheduling preferences of the patient's caretakers. Currently the therapists maintain their own book of appointments, and report their "availability" for new patient appointments on a weekly basis. The approach is both inefficient and ineffective. The "availability" information must be collected every week from 120 therapists at 10 different satellite locations. It is outdated by the time it is delivered to the schedulers. Its saw tooth nature makes it difficult to parse by opportunity window and therapist skillset. The information is reported defensively, with fear of over-scheduling. The number of OT/PT appointment slots reported as open and available for booking is incomplete, and varies unpredictably from week to week (Guo, Wagner, and West, 2004). Scheduling delays of more than 30 days are common. The patient case load is distributed unevenly and unfairly among the therapists, and with little regard to their career skillset preferences. The 65% billable time house rule computations are also being distorted. Patient abandonment rates are very high. Fifty percent of new patient referrals do not complete their evaluation, and more than 20% of all treatment sessions have to be rescheduled.
2. *Implement The Softslot Concept.* Softslots significantly increase the odds of a successful patient booking. They also protect the therapist from overwork and an unfair distribution of the patient caseload. With softslots, every appointment slot in the calendar can be considered without defensiveness arising out of fear of over-work. Patients will tend to have better outcomes because they are more likely to be seen when needed, and sooner. Softslots also build therapist goodwill because they make it possible for therapists to rewarded and recognized for the full measure of their efforts. Until workload-based software scheduling can be implemented, the softslot count for every therapist can be easily tallied temporarily in spreadsheets.

3. *Replace Billable Time Accountability With Workload Computations.* Replace the current house rule that 65% of the time a therapist is available for work must be billable with a target 100% workload rule. The 65% billable time rule does not reward patient outcomes, and is counter-productive as a means of measuring therapist productivity. The billable time approach is insensitive to the true man-hour efforts of therapists, and abusive of their training and goodwill. It leads to therapist dissatisfaction and turnover, the perception of under-appreciated man-hour efforts aimed at better patient outcomes, and resentment from an un-even distribution of the patient case load among all therapists. The workload concept pre-empts all of these problems. The workload concept detaches the billable time reported to payors from the work time of the therapist. It allows for workhour credit for the time a therapist spends preparing for and following-up on the evaluation and treatment sessions they have hosted. It gives credit where credit is due, helps balance the patient caseload among all therapists fairly and equitably, and
rewards patient outcomes instead of patient face time. To start, allow 1.5 workcredit
hours for ever hour billed as a treatment session, and 4 workcredit hours for every hour
billed as an evaluation session following a patient's initial referral. Also instruct the
schedulers not to book any one therapist for more than 4 evaluations per week. Adjust as
needed until the 100% target workload is met routinely. Given the current house case
load, statistically, no therapist will ever be over-worked, and no new referral, evaluation,
or treatment appointment request will be denied.

4. Add Controls That Measure The Quality Of Patient Scheduling. Additional
controls beyond therapist billable time productivity are needed. These additional controls
must be expressed in terms of patient-outcome and caretaker-relevant metrics: (a)
percentage of new patient referrals scheduled for a new patient evaluation; (b) percentage
of booked new patient evaluations actually hosted; (c) average number of times a
scheduled evaluation had to be re-scheduled; (d) average number of days elapsed by
location from the date of the patient's initial referral to the day of the patient's scheduled
evaluation; (e) average number of days elapsed by location from the date of the patient's
initial evaluation to the day of the patient's first scheduled treatment session. When data
for caretaker preferences becomes available, add (f) percentage of evaluations hosted at
the caretaker's preferred location; and (g) percentage of treatment sessions hosted at the
caretaker's preferred location.

5. Give The Caretaker A Voice. The current OT/PT patient scheduling cycle is
much hampered and delayed because the caretaker's scheduling preferences are not being
captured for re-use. Capture the caretaker's scheduling preferences in a spreadsheet or database. Provide the caretaker with a means to review and update their own preference information. There is no reason for the scheduler to start farming the caretaker's scheduling preferences information anew for every appointment that must be scheduled. There is also currently no caretaker-friendly input and feedback mechanism in place that lets the patient's caretaker express their satisfaction with the quality of their OT/PT experience, and in the process make suggestions for improvement. Create a caretaker satisfaction survey and ask that the caretaker fill it out before the end of every treatment cycle plan, and on a monthly or quarterly basis for patients needing therapy over extended periods of time.

6. **Conduct A Survey Of Caretaker Appointment Preferences.** The caretaker appointment preferences are not currently being met. Staff report a disproportionate number of appointment requests for later in the afternoon, and midweek, but are not able to provide quantitative facts in support of their field observation. A caretaker survey would document the particulars of the skewed distribution, and so help schedule the therapist's workday in a way that would better meet the caretaker's appointment needs.

7. **Implement Off-Shift, Blocked, Quiet Time, And Barbershop Hours.** The caretakers have to balance conflicts with daily personal and family events with the need to schedule an OT/PT appointment for the patient. Yet, despite being housed in a 7 x 24 hospital campus, the OT/PT facility is currently only being used for patient appointments Mondays through Fridays between 8 am and 5 pm. Off-shift, designated time blocks,
reporting quiet time, and barbershop hours are all ways improve the house appointment throughout which are currently being under-utilized. Unlike factory floor machine time, which must be carefully planned in advance, odd time shifts for the rendering of patient services can easily be captured and tracked for use with simple software. Under off-shift scheduling, full- and part-time therapists with personal and child-care would be given greater freedom to work in off-shift arrangements that better suit their personal lifestyles and commitments. Example would be late workday starts and departures, or mid-day shifts, or half-day Saturdays in exchange for a three and a half day weekend, including the full day off the following Monday and Tuesday. Under block scheduling, evaluations as single-session events would preferentially be booked on Mondays and Fridays so recurring treatment appointments can be preferentially booked on the mid-week days, where they are less likely to have to be rescheduled because of conflicts with federal and school holidays. Under quiet time scheduling, there could be for example a house rule that the less popular appointment blocks, for example between 10 am and 1 pm, should be scheduled only on an exceptional basis, and so freed for quiet time research and un-interrupted evaluation reporting and SOAP note updates. Under barbershop hours, OT/PT appointments would be offered Tuesday through Saturday, and with the facility closed on Sundays and Mondays.

8. Separate Patient Care From Patient Greeting. Follow the example of dental practices: the office staff greets and processes the patient, the hygienist takes the patient to and from the dentist's chair, and the dentist cares for the patient chairside. Appointment scheduling is done by the clerical staff, not by the dentist. There is no need
for the therapist to meet the patient party in the lobby at the beginning of every OT/PT session, as is the current house practice. The welcome and greeting can be extended chairside. Instead of meeting the patient party in the lobby, implement a Welcome Center manned by patient facilitators, as shown in Figure 26. The facilitator takes the patient party to and from the Care Center. The therapists meet the patient chairside in the Care Center, where they are shielded from disjointed three-way information sharing, time-consuming distractions, and tiring frustrations.

9. Separate Patient Care From Patient Scheduling. At the end of every therapy session, the therapist need simply provide follow-up instructions to the patient party, and record in software that the patient needs to be seen again, and with what frequency. Let the scheduler resolve the particulars of the patient's next appointment in an off-line discussion with the caretaker. Enhance the back-office role of the schedulers by making them customer-facing patient facilitators to protect the therapist's role from misuse. Establish their presence in an open pit welcome station in the lobby, and give them a patient-friendly mindface and authoritative voice when on the phone with the patient's caretaker. The approach will focus the scheduling effort on the scheduler, and so reduce the mis-use of the therapist's time and significantly decrease the disorganization and frustration brought about by three-way communications and the weekly timeslot availability reporting circus. By separating patient care from patient scheduling, instead of being therapist-centered and abusive of the therapist's skill and time, the scheduling of OT/PT patient appointments will quickly be re-directed to be centered on the patient's
medical needs, honor the caretaker's appointment location, weekday, and daytime preferences, and so help the therapist achieve better outcomes for the patient.

10. **Review The Number Of OT/PT Therapists.** The house currently employs some 120 OT/PT therapists at 10 service locations. But the simulations showed that there is only enough work to keep some 75 full-time therapists busy with an average 68% workload (3 evaluations and 18 treatments per week). Even after allowing that half of the current therapists may be half-time, and that 10-15% of all therapists are away sick or on vacation during any one week, there still appears to be therapist overstaffing. The over-staffing may be rooted in the defensive under-reporting of appointment slots available for booking in the weekly availability reporting cycle. There also seems to be some confusion on the reporting of "hours available for work" and the computations of 65% therapist billable time. The questionnaire in Appendix A shows that there is an expectation from supervisors each therapist conduct 3-10 patient evaluations per week, with 1 in a "slow" week and 20 in a "busy" week (presumably including orthopedic PTs conducting group screening evaluations). However the OT/PT facility also reports generating only about 150 new patient referrals per week, and the same supervisors report half of these referrals never produce a hosted and so billable evaluation session. If only a subset of (more experienced) therapists is permitted to conduct evaluations, the sub-group of evaluation therapists could be quickly overworked, while other therapists have nothing to do, because the house for Continuity Of Care considerations prefers to have the same therapist who conducted the evaluation also host the follow-up treatment sessions. Assuming instead all evaluations are randomly distributed to every therapist on staff, on
average there is at best a need to schedule only \(150/120 = 1 \frac{1}{4}\) weekly evaluations per therapist per week, with half ending up to be no-shows and so not creditable as billable time or part of the therapist's workload for the week. Similarly, Appendix A shows a therapist is expected to host between 25 and 35 treatment sessions a week. However, the average number of treatment sessions generated by each new patient evaluation was also reported in the questionnaire to be only 6. Even though the range "may vary tremendously," it is still the average. So based on these number on average each therapist will have only 7-8 billable sessions per week, and at best only \(8/40 = 20\%\) of the average full-time therapist's hours available for work will be billable. This low number is in line with what was found with the initial simulations, but much below the 65%-100% billable time house expectation of supervisors reported in Appendix A (3-10 evaluations per week plus an additional 25-30 treatment sessions in a 40-hour workweek). It is possible the "hours available for work" concept is understood differently by supervisors and therapists. The therapists seem to believe they can meet the 65% billable time rule by booking 2 out of 3 (66%) of the hours they choose to make available for OT/PT appointments. If they only make 3 hours available each week for new patients, and the scheduler is able to book 2 of them, they have met their 65% billable time quota for the week. They are free to self-apportion the rest of their time during the workweek for "other responsibilities" (Guo, Wagner, and West, 2004). The supervisors in contrast are led to believe their staff are overworked because the schedulers are starved for open appointment slots, and so have hired more therapists.
5.7.2 Tactical Opportunities

1. *Implement Patient-Centered Scheduling*. A new, patient-centered scheduling initiative is needed which returns the scheduling function fully to the schedulers and makes better use of therapist's time. The marginal cost of providing a OT/PT therapy session is low, and the therapists are on fixed salaries but are not being fully booked. The new initiative must streamline the processing of new referrals, be responsive to the scheduling preferences of the patient's caretakers, and implement Separation Of Duties in a way that will support and lead to the eventual automation of the OT/PT patient scheduling process. The arrival rate of new patients, and the overall house patient case load is such that by simply telling the schedulers not to book any one therapist for more than 3 evaluations per week, no therapist will be over-worked, and no new patient referral will be denied. The approach will decrease the rate of no-shows and cancellations because the appointments will have been set to be convenient to the patient's caretaker, instead of convenient to the therapist. The approach will also dramatically curb the waste of under-reported and so unused available appointment slots. The literature very clearly documents that when care providers are allowed to self-schedule their own "hours available for work," they flee to what they perceive is more interesting and rewarding work, report unpredictable and wildly changing open slots from week to week, and on the whole make disproportionately little time available for the scheduling of patient appointments. For example, in a study of an ophthalmic child patient population, the week-to-week appointment slots reported as available for patient appointments fluctuated by a factor of five: "*overall provider availability is highly variable, with the total*
number of weekly slots among all doctors varying between 137 and 622” (Guo, Wagner, and West, 2004).

2. Implement The Welcome Center Concept. The concept of a Welcome Center can be implemented immediately at all but the smallest service location. No new staff need be hired. The Welcome Center can be staffed by having the current back-house schedulers man an open pit counter area in the lobby where they can function as patient-facing caretaker and appointment facilitators. The open pit will let them greet and dispatch the patient party in a welcoming and friendly manner. They will also be able to move about freely, for example, to take the patient party to and from the Care Center, and help the care taker use a touch-screen kiosk to record their scheduling preferences for follow-up appointments. The Welcome Center frees the therapist time and reduces therapist frustrations so that they can concentrate on medical care that is billable. Failure to make a patient and caretaker feel welcome, particularly when they are poor, is at the core of high levels of patient abandonment: "No-show rates were estimated to be 5% for commercial patients [who pay well] whereas Medicaid/self-pay patients have a 20% no-show rate for new appointments and a 50% no-show rate for follow-up appointments" (Guo, Wagner, and West, 2004).

3. Implement A Modern Web-Based Patient Referral Capture Interface. Currently physician referrals are processed largely by the means of pre-printed forms and paper prescriptions. The referrals are usually faxed in by the patient's primary care physician. Faxing is a 1980's technology, and the advance distribution of paper forms is archaic,
ineffective, and inefficient. A secured website designed to let physician's offices submit OT/PT patients electronically would rapidly increase the primary physician care base able to submit new patient referrals to the OT/PT division to the entire hospital's service area. It would also decrease information flow discontinuities from frequent call-backs for clarification, imprint a technologically modern house brand and the perception of accessibility in the mind of the caretaker as the decision makers, and make it possible for a larger percentage of potential new patients to be booked sooner for an OT/PT evaluation.

4. Add An Electronic Therapist Skillset Tracking Interface. The current OT/PT appointment scheduling workflow throughput is severely restricted by the inability of the schedulers to easily determine what the house OT/PT skillset distribution is by therapist and location. Therapists are also not supported in their career goals and aspirations to emphasize certain skillsets over others. With a volume of about 150 new patient referrals per week being processed by only one or two specialists, it is clear the referral processing step bottleneck could be helped significantly by adding an electronic interface with know-how capture and memory retrieval of previous OT/PT therapist assignment decisions. Currently large numbers of patients are not being served in a timely manner, billable appointments for evaluations and treatments are not being booked in a timely manner, and patient abandonment rates are high, simply because of the delays caused by (a) the current referral processing know-how bottleneck, and (b) the fact that the schedulers cannot easily determine what medical skillset each therapist can make available in house at the main facility, and at each of the more than 10 OT/PT satellite
area locations the hospital serves. The literature is very clear on the issue of delays: one single delay begets multiple subsequent delays, and significantly higher rates of cancellations and no-shows (Sonnenberg and Crain, 2005). A OT/PT therapist skillset computer interface would much simplify referral processing and patient scheduling, and so reduce these detrimental scheduling delays.

5. **Implement The Therapist Center Concept.** The Therapist Center makes it easy to stop mis-using the therapists as Wal-Mart greeters and patient schedulers. The OT/PT therapists are too expensive and over-educated a resource to be used in this way, and they quickly grow frustrated, defensive, and unproductive from the abuse. Instead, (a) adopt the dental office patient shopfloor processing model. The Welcome Center greeters take the patient party to and from the Care Center, and the therapist meets and leaves the patient party in the Care Center. Figure 25 illustrates the concept. And (b), provide an electronic computer interface to the therapists which they can use to flag their OT/PT appointment roll-over decision after hosting a patient evaluation and treatment session. The therapists should be able to use this same interface to report when they will be on vacation or plan to take a day off, and also to see for themselves that their patient case workloads are being properly accounted for, that their career skillset preferences have been properly recorded, that the house patient case load is being fairly and equitably distributed among all therapists at all house satellite locations, and that they are recognized and appreciated for patient outcomes far more than they are for their billable hours.
6. Implement A Caretaker Preferences Capture Computer Interface. Capture the caretaker preferences with a computer interface so that the number of telephone exchanges and caretaker frustration with a phone tree can be reduced. The interface should be web-enabled, so the caretaker can access it from work, home, or a touch-screen lobby kiosk. Let the caretaker register and rank their appointment weekday, time, location, start date, and turnover date preferences, in similar manner to the way a passenger in an airliner can book a seat reservation. Also let the caretaker review the patient's appointment history, and report on the need to re-schedule an appointment. If there is concern there will be too many re-schedule requests, impose a nominal, small and often waived change fee, like airlines do when you want to change a booked flight. The fee should be used as a psychological tool, with "frequent-flyer" house reward points, not as a revenue-gathering one. The preferences can then be used and re-used by the scheduler as the patients returns for, and inevitably re-schedules subsequent OT/PT appointments. The computer interface should be accessible from a kiosk in the Welcome Center of Figure 26, where the caretaker can be aided and trained by the patient greeters and caretaker facilitators.

7. Implement The Workload Concept. The current use of billable time as a productivity control metric does not take into account the difference in man-hour effort required by a therapist to properly tend to an evaluation and a treatment session. It rewards therapists for billable time instead of patient outcomes, and encourages the misuse of therapists as schedulers. It is also dependent on the therapist's available hours for work, which do not seem to be properly captured, and the perception of an inequitable
workload distribution compared to other therapists, which leads to resentment and the tendency to defensively micro-manage their own work-hour availability, much to the detriment of the patient's appointment options. The workload metric gives explicit recognition credit for the therapist's efforts to achieve a better patient outcome. It helps balance the patient case load fairly and equitably among all therapists. Importantly, as demonstrated earlier, because workload-based scheduling uses soft slots, it also improves the odds of a successful patient booking. The workload concept also returns the scheduling function fully to the schedulers. The therapists no longer have to report their "availability" every week, and so are freed from this weekly chore, and from patient-based scheduling woes. With workload accountability, no therapist will ever be overbooked and so overworked. The patient case load will be divided fairly and equitably among all therapists. The implementation of the workload concept will also quickly reverse the significant revenue losses experienced by the OT/PT division from the large numbers of new patient referrals, evaluations, and treatment appointment requests currently being unjustly denied booking.

8. *Learn Pricing From The Airline Industry.* It appears access to OT/PT care is being disproportionately denied to patients with fragile socio-economic profiles. A disproportionate number of the 50% no-show evaluation session cases, and 20% no-show treatment session cases reported by the OT/PT staff, consists of Medicaid and uninsured patients (Guo, Wagner, and West, 2004). The medical needs of these patients are not being met because they are not made to feel welcome, and the scheduling needs of their caretakers as their support infrastructure are being glossed over. It should be possible to
improve access to care by this population segment by introducing a sliding fee payment schedule that is tied to the patient's ability to pay, and advertise its existence. Similar to airline seat reservations, further differentiate your payment scale based on whether caretaker demands a specific appointment slot, or is flexible, and whether the caretaker is seeking to book an appointment early or late. In addition, it costs money to fly an airplane. The Medicaid reimbursement rate negotiations must be based on therapist workloads and patient outcomes, rather than the size of the therapist payroll and the cost of individual procedures (Pear, 2007; Pérez-Peña, 2007).

5.7.3 Strategic Opportunities

1. **Outsource The Patient Scheduling.** Once the referral recommender, therapist skillset and caretaker preferences capture, and therapist interfaces have been built, the OT/PT division will be operating under Separation Of Duties. The next step is to remove the patient scheduling function from the daily medical functioning of the OT/PT division by outsourcing the scheduling of the house OT/PT patient case load. Scheduling is not a core competence of a medical facility. Medical care is.

2. **Move To A Self-Contained Stand-Alone Facility.** The OT/PT division has outgrown its facilities at its current location. It does not offer convenient parking and is far removed from the population growth of the surrounding urban community. Building access is awkward, and patient and therapist quarters are cramped. One of the satellite facilities in a population growth area already has about the same number of therapists as
the main facility. The OT/PT main offices should be moved to larger quarters in this
satellite facility, with more convenient patient access and parking, if possible in a stand-
alone building. The current "main location" should become just another satellite facility,
albeit one with close and specialized ties to the patients referred from the rest of the hospital.

3. Obtain Funding To Computerize The OT/PT Division. The current information
flow discontinuities in information needed for patient referral processing, caretaker
appointment preference capture, the tracking of therapist location and skillset
distributions, and the ready identification of "open slots" available for scheduling, are all
very wasteful and disruptive of the daily functioning of the OT/PT division, at the
operational, tactical, and strategic levels. The OT/PT division is not being anywhere near
properly funded to the level needed to update its workflow processes, cover its patient
volume, meet the expectations of staff, support a 10-satellite location service
architecture, and otherwise support its extensive computerization needs. Funding for a
new turn-key strategic initiative aimed at computerizing the specialized needs of the
OT/PT division's OT/PT patient scheduling and processing workflow is needed rather
urgently.

4. Introduce Open House Scheduling. The mission of the OT/PT division is to
provide medical care to OT/PT patients. Adopt a friendlier and more open-stance patient
scheduling philosophy. Let medical need dictate access to medical care, not the patient's
ability to pay. There seems to be an undue preoccupation with patient eligibility and pre-
authorization issues, and self-serving therapist demands, and not enough focus on meeting caretaker expectations and patient medical needs. As has already been done in the field of education, admission decisions must be kept separate from financial aid considerations. The outcome of this dissonance is high rates of OT/PT patient abandonment (Guo, Wagner and West, 2004). The reality is that the OT/PT's marginal cost for the provision of evaluation and treatment sessions is small in the operational context of a 12-facility OT/PT division. Adopt the philosophy of getting the patient evaluated and treated first, and worry about eligibility, authorizations, and payment issues later. Make authorizations part of the billing cycle, as done in this study, instead of the scheduling cycle, as is currently done. The payment issue will resolve itself eventually. Wider use of sliding-fee payment scales, adoption of the Welcome Center, and the added revenue and community goodwill from increased booked and billable traffic, will offset the incremental marginal cost of the occasional un-reimbursed appointment. The cost of the staff man-hours wasted pre-qualifying the patient in advance for insurance re-imbursement purposes for an appointment with a high probability of being cancelled or becoming non-billable because a no-show is higher than the marginal cost of hosting an OT/PT appointment that for which a third party after late inquiry refuses to pay. In addition, the OT/PT service effort must be scaled to meet even higher population-level scheduling needs. Higher pediatric patient volumes are expected from generational demographics, and restrictions on medical access by children continue to be relaxed and entitlement eligibility ceilings raised (Pear, 2007; Pérez-Peña, 2007).
Figure 24. The OT/PT patient Welcome Center concept.
Chapter 6 - Conclusions And Follow Up

This study sought to build on the early patient-centered scheduling vision of Bailey and Welch (Bailey, 1952; Welch 1964). It uses Separation of Duties to merge the thinking behind state-of-the-art internet data packet routers with that of supply chains. The approach introduces a paradigm-shift in the scale and quality with which OT/PT therapy appointments can be scheduled. The current artisan-level, manual, and therapist-centered scheduling of OT/PT appointments is converted to a population-level, automated, and patient-centered OT/PT system. New patient referrals, evaluations, and follow-up treatment sessions can be scheduled more easily and conveniently, with greater medical benefits and at a lower cost.

This chapter first summarizes the study, and draws some conclusions. It also names some of the contributions and benefits of the study at the operational, tactical, and strategic levels. It closes with the presentation of a new vision for the scheduling of OT/PT patients suggested by the work, and a list of opportunities for follow-up funding.

6.1 Summary

This study abstracts and transforms the often heart-breaking scheduling details of a daily reality into a simple architecture that lends itself to the automated scheduling of entire patient OT/PT patient populations at a time.
The transformation in mode and scale advanced in his study is enabled by the replacement of seven anthropometric OT/PT appointment booking roles (patient, caretaker, referral specialist, therapist, scheduler, payor, and administrator) with an abstracted set of appointment requests and appointment bookings stored in and routed by two set of intelligent queues.

The first set of queues contain OT/PT evaluation and treatment appointment bookings. The lifetime of any booked appointment in the queue is very short. It is limited to one scheduling cycle. The scheduling cycle is rotated as the calendar advances, and so produces a book of OT/PT appointments that can cover daily, weekly, and monthly OT/PT appointment frequency variations.

The advantage of the small book of appointments is that it enables high slot booking rates in the face of high rates of cancellations and now shows. Their short horizon eliminates the need to avoid conflicts with, propagate, and cascade-clear hollow future appointments. It also makes it possible to abide responsively by the discretionary decisions made by the therapist at the close of every OT/PT session as to whether to extend or curtail a patient treatment series or return frequency.

The items in the booked appointment queues are disposed of when dequeued based on a simple and pre-defined appointment outcomes logic. The logic is based on whether or not the OT/PT appointment was held and so is billable, whether or not a follow-up appointment is needed and warranted, and what location, weekday, and timeslot under continuity of care considerations will most closely meet the medical needs of the patient, match the scheduling preferences of the patient's caretaker, and provide for
a fair and equitable distribution by location of the patient case load among all therapist skillsets.

The booked appointment queues are enqueued by the intelligent processing of appointment request streams originating from the second set of queues. This second set of queues contains the referral, evaluation, and treatment appointment requests that need to be booked.

The appointment requests in the second set of queues are expressed in terms of six routing-oriented parameters: a patient identifier, and flag or counters for the type of appointment (evaluation or treatment), frequency (daily, odd, weekly, every other week, or monthly), age in queue (number of earlier scheduling attempts), scheduling status (new, scheduled, billable, or abandoned), and number of previously missed appointments.

The appointment requests in the second sets of queues are randomized or ordered as needed, and then polled as called for by their scheduling frequency flag at the beginning of every new scheduling cycle. Daily appointments can be rolled over every night, odd ones on reaching a count, weekly ones at the end of every week, and so on. The scheduling cycles are repeated as the calendar advances, until the entire OT/PT population has been scheduled and re-scheduled for all scheduling cycles, and can begin anew.

The intelligent routing of the appointment requests in the second set of queues ages and cross-matches the patient's medical needs, the therapist's OT/PT designation, skillset, and workload, and the caretaker's weekday, time, start day, location, and location turnover preferences in a very selective way. The result is an automated process which fairly and equitably distributes the patient case load among all therapists at all locations.
The mechanism uses softslots to increase the probability of a successful OT/PT appointment booking, and workload computations to ensure the equitable patient case load distribution across multiple facilities in a way not achievable by tracking therapist billable time alone.

The new OT/PT patient scheduling system was implemented in software. Experimental runs parameterized with information from a case study conducted at a large OT/PT facility demonstrated that the new scheduling system successfully produced a revolving book of OT/PT appointments, and was well-behaved under a variety of parameter mix scenarios.

The OT/PT facility used for the case study is affiliated with a large regional hospital which schedules more than 25,000 patient appointments per year with some 125 OT/PT therapists at 10 different service locations. Adoption of the new scheduling system described in this study promises to significantly benefit this OT/PT facility, and similar ones, at the operational, tactical, and strategic levels.

6.2 Conclusions

1. Change In Mode. The initial patient referral is streamlined because assisted by a recommender which captures the know-how from earlier patient assignments to OTs or PTs. The patient's medical needs are met sooner, with fewer appointment cancellations and no-shows, because the caretaker's appointment preferences are captured and taken into account from the beginning of the scheduling effort. The patient case load is distributed and balanced fairly and equitably among all therapist skillsets at all therapist
locations. The book of OT/PT appointments is the smallest and so the most flexible possible, one scheduling cycle, for every calendar frequency, from daily to monthly. Separation of Duties and the resulting automation by queue abstraction and intelligent routing makes it possible for schedulers function as appointment facilitators, and for the therapists can concentrate exclusively on billable medical care. The payors and administrators gain access to enhanced, more timely and detailed productivity control metrics that can be used to reduce costs and improve access to medical care.

2. Change in Scale. The current OT/PT scheduling system is a micronetic one, based on anthropometric roles and artisan-level production of pediatric OT/PT appointments. OT/PT appointments are booked by juggling the seven anthropometric roles of patient, caretaker, referral specialist, therapist, scheduler, payor, and administrator to a match, one OT/PT appointment at a time. In contrast, the new OT/PT scheduling system advanced in this study is a macronetic one, based on abstracted queues, intelligent appointment request and appointment booking routing. It transforms the OT/PT appointment scheduling space so that the scheduling mode is changed from the earlier role-based, state-driven, and haphazard scheduling mechanism becomes a process-based, event-driven, and optimizing one. It also changes the scale of OT/PT appointment scheduling from the artisan-level to the population-level.

3. Advanced But Practical. The simulations of the scheduling of the patient case load for the OT/PT facility in the case study demonstrated that the abstracted OT/PT appointment request routing and booking had rollover selectivity and balancing
intelligence. The scheduling system successfully routed requests for referrals, evaluations, and treatment appointments, and enqueued and dequeued appointment bookings as the calendar advanced with the smallest book of appointments possible, and in a way that (a) first considered the medical needs of the patients; (b) factored in the preferences of the patient's caretakers; (c) captured the know-how of the referral specialist; (d) tracked the skillsets and (e) computed the workload limitations of the therapists; (f) created an audit trail to serve the accountability needs of payors, and (g) made available a rich set of control metrics to help administrators drive the functioning of the OT/PT facility in the service of its mission to provide access to OT/PT medical care.

6.3 Contributions

1. *Introduces The Concept Of A Therapist Workload To OT/PT Patient Scheduling.* The workload concept extends the concept of therapist billable hours to explicitly account for the incidental time that is associated with each patient evaluation and treatment session. The workload concept permits the definition of house rule productivity levels with built-in protection for the therapist from overbooking. It also fairly and equitably balances the house patient case load among all therapists at all OT/PT satellite service locations.

2. *Introduces The Concept Of Softslots To OT/PT Scheduling.* The target workload is controlled by the use of softslots. Softslots are appointment slots which exist only in software. They are reserved but not actually booked. The flexibility in
appointment setting enabled by softslots increases the probability of a successful booking compared to a time set-aside reservation system. Because the softslots can be displaced by a conflicting subsequent appointment request for an actual appointment, they improve the odds of a successful appointment booking over what would be likely when the therapists maintain their own book of appointments.

3. **Introduces The Concept Of Separation Of Duties To OT/PT Scheduling.** The use of Separation of Duties makes it possible to created secured, independent-channel workviews which are attractively specialized to meet the needs and expectations of every stakeholder in the OT/PT patient scheduling process. There is a patient view, a caretaker view, a referral specialist view, a scheduling facilitator view, a therapist view, a payor view, and an administrator. The views have information value to the stakeholder and permit the stakeholder to input information they know and review information they care about. At the same time, the views are not cluttered or undermined by interference from extraneous information. The capture of the information and the use of the information are kept in separate, non-interfering channels. For example, the appointment slots made available for booking by the patient are controlled by the computerized administration of the therapist's workload, not by the therapist's self-apportionment of appointment slots for evaluation and treatment based on their billable time availability.

4. **Clearly Defines The Role Of Every Stakeholder.** The OT/PT patient is not subjected to pre-emptive eligibility reviews and pre-authorization gauntlets, and so is more likely to be seen, and to be seen sooner. The caretakers gain access to a Patient
Dashboard through which they can assert their scheduling preferences and review, make changes to their appointments, and generate printouts to stick on the door of the refrigerator in their kitchen. The referral specialist is assisted by an OT/PT Recommender. The schedulers are relieved of logistical scheduling responsibilities. They are moved to a Welcome Center and become people-level patient facilitators, visit coordinators, and information communicators. The therapists meet patients exclusively in the Care Center, and so can concentrate on medical care.

5. Shows How To Minimize The Size And Planning Horizon Of The Book Of Appointments. The automated scheduling is limited to a single scheduling cycle at a time, and so the size of the book of appointments is minimized. Different follow-up appointment frequencies, daily, odd, weekly, every other week, and monthly, can be accommodated very simply, by overlaying appointment scheduling cycles as the calendar advances, for example at the end of every day for daily appointments, at the end of every week for weekly appointments, at the end of every month for monthly appointments, and at the end of every count for two, three, and four time a week appointments. Frequent no-shows and cancellations are not as destabilizing. The short horizon eliminates the need to avoid conflicts with, propagate, and cascade-clear hollow hard-scheduled future appointments, yet it retains the therapist's discretion at the close of every OT/PT session to extend or curtail a treatment series. There is no appointment book to change when a therapist changes her mind about the duration or frequency of a treatment plan, takes a day off, makes use of a holiday, or goes on vacation.
6. Shows How To Abstract The Mode OT/PT Scheduling Into A Transformed Space Suitable For Intelligent Automation. The OT/PT patient scheduling space is moved from the realm of self-interested and state-aware anthropomorphic roles (patient, caretaker, referral specialist, scheduler, therapist, payor and administrator) to a realm of abstracted, disinterested, event driven, goal seeking appointment request and appointment booking processing. In the abstracted space, specialized queues are enqueued and dequeued by intelligent logic. The transformed space converts the thinking from a therapist-centered one focused on state and exceptions to a patient-centered one focused on events and process. In the transformed space, the scheduling engine is no longer a human scheduler who must make an N-way match from among billions of possible OT/PT permutations with incomplete information and through fractured communication channels. Instead, the scheduling is done by an unbiased and information-rich computer with built in sequencing, prioritizing, and routing intelligence. Only the people-level communication, information sharing and welcome facilitation functions remain with the human scheduler. The actual OT/PT patient scheduling is automated.

7. Shows How To Transform The Scale Of OT/PT Appointment Scheduling From Artisan Level To Population Level. The abstraction of patient scheduling from anthropometric roles and the ensuing transformation of the scheduling space in terms of the automated routing of appointment requests and appointment bookings by roll-over polling intelligent routers and prioritized queues changes the scale of the OT/PT patient scheduling process from a micronetic to a macronetic one. The scheduling paradigm shifts from one based on artisan appointment setting done by trial and error and in the
presence of incomplete information and cross-interferences, to one that is electronic, intelligent, balanced, optimizing, and suitable for large-scale automation of entire patient populations.

8. *Facilitates Access To Care And Reduces Costs.* The patient-centered model increases patient access to care. OT/PT appointments are scheduled based on the medical needs of the patient, the caretaker scheduling preferences, and a comprehensive view of the availability of a specific therapist OT/PT skillset at every OT/PT service location. The payors are freed from individual patient eligibility tracking, and can focus on cost containment by negotiation based on highly leveragable cost controls tied to population-level aggregates, averages, comparisons, and trends tied to a large-scale electronic commodities market for the pricing of OT/PT therapy services. The administrator gains an enterprise-level view of the OT/PT facility's functioning at multiple locations, with electronic access to multiple control metrics and reporting geared to fact-based measurements of facility efficiency and mission coverage collected without the need of operator data input.

### 6.4 Operational, Tactical, And Strategic Impact

As detailed in the next several sections, the implementation of the new OT/PT patient scheduling system is expected to have a significant impact on the operation, tactical, and strategic functioning of pediatric OT/PT outpatient scheduling.
6.4.1 Operational Impact

1. *Improves Continuity Of Care.* The availability of information about the caretaker's preferences and the effort of the automated scheduling engine to abide by these preferences when scheduling OT/PT referrals, evaluations, and treatments makes it more likely that the patient will be seen sooner, and at the more convenient location preferred by the caretaker. It thus also makes more likely that the patient will miss and have to reschedule fewer appointments. The comprehensive overview retained by the automated scheduling engine of all appointment slot options by therapist skillset and location, and the workload-balancing selectivity of the roll-over booking intelligence also make it more likely that the same therapist who hosted the patient's evaluation will also host the patient's follow-up treatment sessions. A change in location, and so therapist, for example from a preferred location to the hospital's main location, is only attempted when the change would there would otherwise be an unacceptable delay in access to care.

2. *Increases OT/PT Therapist Billable Time.* By remaining in the Care Center, and having the patient brought to them in the manner of a dentist's chairside visit, the OT/PT therapist frees valuable time, and can concentrate exclusively on case preparation and follow up, and providing billable medical care. The Welcome Center people-level facilitator assumes responsibility for greeting the patient and caretaker, making the party feel welcome, and helping capture the caretaker's preferences for subsequent appointments.
3. **Increases The Probabilities of Billable Bookings.** With the small, single cycle book of appointments there is no need to propagate changes through the chain of forward-booked appointments. Subsequent appointment requests are not blocked by a sea of future appointments which in the end may not be held due to last minute cancellations and no shows. The small book of appointments and the use of softslots also increases the probability of booking a viable appointment because softslots can be displaced whenever needed, as long as therapist workload limits have not already been reached.

4. **Decreases The Size Of The Appointment Book.** The new system keeps the smallest book of appointments possible for a given appointment frequency. There is a single scheduling cycle planning horizon for every appointment regime (daily, two, three, four day a week, weekly, every other week, or monthly). The small book of appointments generated as the calendar advances keeps the scheduling options for recurring appointments and alternate appointments open, and so bookable and billable in a more productive manner. A small book of appointments is an important consideration in the face of high rates of no-shows, cancellations, reduces scheduling errors, and relatively frequent changes in the patient's care plan as the patient progresses as an individual.

5. **Extends Billable Hours Of Operation And Increases Part-Time Therapist Scheduling Options.** The matching of caretaker appointment preferences and the therapist's hours available for work and hours of service takes place electronically. The
electronic match makes it possible to extend the hours of operation of the OT/PT practice in a way that is tuned to the preferences of the patient's caretaker and adaptable to the personal schedule and off-shift work flexibility sought by a part-time therapist. The hours of operation of the OT/PT facility can be extended as a result to late afternoon and early evening, Saturday and even Sunday. Extended hours better serve the mix of interests, needs, and expectations of the patient, the caretaker, and the therapist. Fixed overhead expenses are also distributed over a larger billable appointment base.

6. Protects The OT/PT Therapist From Frustration And Overwork. The introduction of the concepts of workload, softslots, and Separation Of Duties protects the therapist from overwork by over-scheduling, eliminates the distractions and frustrations related to scheduling, and gives credit and encouragement for the therapist's accomplishments in a way that reflects the therapist's actual effort and outcomes, instead of just their billable time.

7. Apportions The Patient Case Workload Fairly And Equitably Among All Therapists At All Locations. The new OT/PT scheduling system fairly and equitably balances the house patient caseload among therapists in an automated matter. There is no resentment from a perception of favoritism or unequal workload distribution by peer skillset or location.

8. Selectively Matches Patient Medical Needs To Therapist Skillsets. The OT/PT appointments are scheduled according to the skillset emphasis of every therapist, as
determined by the preferences of the therapist and the determination of the OT/PT facility supervisory administrators. There is no underutilization of therapist skillsets. The availability of therapist skillset by location and the utilization of every skillset at every location also becomes transparent and so tunable.

9. Distributes The Patient Caseload To Multiple Locations. The capture of the caretaker's weekday, time, location, start date, and turnover date preferences and the detailed knowledge about the number and skillset of every therapist at every location makes it possible to distribute the patient case load to multiple service locations in a manner that tracks evenly with the number of requests for every location. The main location is only used as a supra-cell fall-back service location when needed to expedite the OT/PT evaluation or treatment series initiation, service a patient case referred internally by other medical departments within the hospital, or meet a specific request on the part of the patient's caretaker.

10. Minimizes The Number Of Therapists Needed At Each Service Location. By tracking and balancing the patient load across multiple locations according to caretaker preferences, patient volumes, and within continuity of care considerations, the new system makes it easy to track the therapist skillset distribution and the therapist workload utilization by location. The OT/PT administrator can thus predict the minimum number of therapists needed at every service location, and closely track the overall billable utilization of every location, important issues for large, multiple facility OT/PT practices.
11. **Disambiguates And Simplifies Stakeholder Roles.** By clearly separating the roles of patients, caretakers, referral specialists, schedulers, payors and administrators by the Principle of Separation of Duties, each stakeholder is only asked about information they possess, and they see only the information they are interested in. The frustration and discord raised by disinformation and cross-interferences from information provided by extraneous contexts and mixed channels is eliminated. For example, the schedulers are freed from N-way appointment scheduling logistics and information flow headaches. Instead, the scheduler becomes a people-level facilitator and information communicator who heads the Patient Welcome Center, and so is seen not as an irritant, but as an integral and peer-level member of the professional OT/PT medical team.

12. **Reduces and Simplifies Daily Administrative Chores.** There is no need to collect, compile, and reconcile the "appointment availability" of 120 therapists on a weekly basis from 10 different locations. The new OT/PT scheduling system provides an enterprise level electronic overview of patient medical needs, caretaker preferences, therapist skillsets, locations, and workloads, the number of patient referrals received, the number, therapist, and location distribution of evaluations and treatment appointments held, and automatically rolls referrals into evaluations, evaluations into treatments, and recurring treatment appointments. It also helps administer track patient medical needs, caretaker preferences, therapist skillsets, workload, and billable time, the percentage of referrals filled and the percentage of appointments billed at the caretaker's preferred location, patient wait times in days before a successful appointment, and the number of appointments missed and canceled, all without requiring any operator data input.
6.4.2 Tactical Impact

1. **Benefits The Patients.** More patients are seen, and they are seen sooner, and with fewer care interruptions. There is an electronic match between the patient's medical needs and the therapist's medical skillset.

2. **Benefits The Caretakers.** The new OT/PT scheduling system captures and abides by the caretaker's weekday, time, location, start date, and turnover appointment scheduling preferences. The OT/PT appointment is scheduled so as to be agreeable to the patient's caretaker. The added measure of convenience to the caretaker makes it more likely that the patient will be seen in a timely manner. The caretaker also gains access to a secure, internet-enabled electronic dashboard they can access from work or home to express their scheduling preferences and review and update the patient's appointment schedule. The caretaker should be shown how to use the dashboard from a touch-screen kiosk in the Welcome Center at the time of the patient's initial visit. The caretaker gains access to multiple communication channels with the OT/PT facility (phone, email, chat, kiosk, a human Welcome Center facilitator, and the online dashboard). There is no need to be restricted to a single communications channel, a telephone call mediated by a phone tree. There is also no need for the caretaker to play phone tag with schedulers or therapists.
3. **Benefits The Referral Specialists.** Every patient initial OT/PT evaluation must be preceded by a referral slip signed and dated by a physician. When interpreting the referral slip, the referral specialist functions in similar fashion to a licensed pharmacist who must fill a prescription in a way that will assign the patient's case more properly to a therapist credentialed as an OT or PT (and in infrequent cases, both or neither). The assignment is made by the determination of a preliminary primary diagnosis and the secondary presentations exhibited by the patient. The new OT/PT scheduling system anticipates the implementation of a recommender which will present the specialist's earlier OT/PT assignment history for similar cases, and so make it easier for the referral specialist to make a request to schedule an OT or PT for the patient (or neither or both).

4. **Benefits The Schedulers.** The role of the schedulers is enhanced in a way that lets them function as people facilitators and patient advocates. Their stature is raised and they become respected and integral members of the OT/PT professional staff. Their new emphasis is as communicators, over the phone, and as patient greeters in a Welcome Center. They help the caretaker register their scheduling preferences, or yet do the preferences input for the caretaker, over the phone, or in the lobby with the aid of a scheduling kiosk. They ensure the computer has sufficient and timely information from the capture of the caretaker's preferences, and from the appointment rollover instructions of the therapist, to automatically match therapist skillset, location, and workload to the patient's needs and so book the patient's evaluation or treatment session. At the OT/PT facility, there are fewer staff interruptions and an electronically streamlined flow of information because the scheduler have been freed from their logistical scheduling and
eligibility tracking headaches. Instead, they become patient facilitators and information flow coordinators with fewer frustrations and a more direct impact on the daily well-being of the patient.

5. Benefits The Therapists. In the new OT/PT scheduling system, the patient facilitator takes the patient from the Welcome Center to the Care Center. The therapist meets the patient in the Care Center, chairside like a dentist. At the end of the appointment, the therapist informs the patient's caretaker of their rollover decision, and captures this decision in software. At the end of every appointment, the therapist may ask for example that a treatment session rollover, but with a different scheduling frequency, say every other week instead of weekly. The decision is relayed electronically through software to the OT/PT appointment processing engine so that it can be acted on when the next automated scheduling cycle for that appointment's frequency regime begins. The time freed up reduces the frustration and tiredness of the therapist's day, and so becomes available for more productive uses. For example, the literature has long championed the greater use of evidence-based medicine (EBM) (Sackett, Rosenberg, Gray, et al., 1996; Haynes and Haines, 1998). In the case of PTs, a recent study (Jette, Bacon, Batty, et al., 2003) showed that the therapists agreed that EBM was helpful to their daily practice, and that the quality of patient care was better when evidence was used. However, "according to the respondents, the primary barrier to implementing EBP was lack of time" (Jette, Bacon, Batty, et al., 2003). By freeing the therapist from scheduling responsibilities, and keeping them in the Care Center and out of the Welcome
Center, the therapists will be less tired and frustrated, more billable, and more focused on the patient's medical care.

6. **Benefits The Payors.** The electronic appointment book keeps the patient information secure, but also makes the patient's appointment trail accessible, and their appointment history electronically portable for use external uses, as warranted and appropriate, here for payor review and processing. The payor need only review the medical group membership credentials of the patient, as defined by the patient's primary diagnosis and presentation profile (and not their personal identity as an individual!), and then make payment based on its negotiated terms of service for that profile, if the payor is an institution, or matched rates if the payor is an individual. Both the payor and the OT/PT facility function in a universal access mode, and so are freed from having to track the "eligibility" of individual patients for needed medical care. Instead, the payor and the OT/PT facility can concentrate on cost containment that is highly leveragable, based on contract negotiations tied to aggregated medical population statistics, comparisons, trends, care volumes, and patient outcomes.

7. **Benefits The Administrators.** The electronic nature of the new OT/PT scheduling system, with input from multiple channels which operate independently under Separation of Duties, provides a comprehensive overview of the functioning of the OT/PT facility as an enterprise. Several vantage points and many controls become available which can be used to monitor and drive the OT/PT facility in the service of its mission, all without requiring any operator data input of its daily functioning.
Aggregates, comparisons, and trends can be inspected in real-time views. Examples are (a) the workload and OT/PT skillset mix of therapists; (c) average and outlier patient wait days for evaluations and treatments; (d) numbers and percentage of referrals converted to evaluations, percentage of evaluations converted to follow-up treatment plans, and the percentage and distribution of treatment plans completed, and (e) main and satellite location usage, and the therapist skillset distribution by location. The review of no-input reports, the use of simple what-if electronic scenario experiments, and the exercise of simulations made possible by the electronic nature of the OT/PT scheduling system can all help keep the functioning of the OT/PT facility aligned with its mission of providing OT/PT medical care.

6.4.3 Strategic Impact

1. **Ensures OT/PT Medical Care Mission Drives Its Functioning.** The new OT/PT scheduling system described in this work processes appointment requests and generates appointment bookings by means of intelligent routers and queues. These routers and queues abstract anthropometric roles and so are immune to information discontinuities and cross-purpose interferences. They collect logistical scheduling information from channels which are kept separate and independent. They then use simple rules to automatically generate a short-horizon book of OT/PT evaluation and treatment appointments from a fresh set of referrals, backlogged evaluation and treatment requests, and the outcomes of earlier appointments. The repetition of scheduling cycles as the calendar advances makes available electronic information for enterprise-level
administrative reporting, decision making, and pricing without requiring any operator
data input. The abstraction and automation ensure that the daily functioning of the
OT/PT facility is subsumed to its central mission, the provision of OT/PT medical care.

2. Enables A Paradigm Shift In The Mode And Scale Of OT/PT Scheduling.

Automates the scheduling of patient referrals, evaluations, and treatment session on a
scale suitable for the scheduling of entire patient populations at a time. Logistical
scheduling selectivity is obtained easily from a small number of parameters assigned to
data obtained by separate channels under the Principle Of Separation Of Duties. Secured
separate channel interfaces are anticipated to register the medical needs of the OT/PT
patients, the location, weekday, and time preferences of the patient's caretakers, the
holiday, illness, and vacation schedule therapists, payors and administrators. The
intelligent routing of appointment requests and booking through queues changes OT/PT
patient scheduling from a therapist-centered scheduling model driven by therapist
availability and billable time to one centered on the patient. The approach separates
medical care from scheduling and payment considerations while enabling an aggressive
cost-containment capability that is friendly to payors and a detailed reporting profile that
is helpful to the OT/PT facility administrators. It also changes the scale of appointment
setting from the individual level to the population level. The new scheduling system
learns from earlier referral specialist's decisions and is driven by workload considerations
which consider the patient's medical needs first, respect the caretaker's weekday, daytime,
start date, location, and location transfer window preferences, protect the therapist from
overbooking, and provide a fair and equitable distribution of the patient case load among all therapists at all locations.

3. **Facilitates HIPAA portability and eGovernment Electronic Health Record Automation.** The approach in this work enables greater medical record automation and electronic clearing and so fosters the greater electronic portability and traceable accountability sought by eGovernment initiatives such as FACTA and HIPAA. Instead of operating at the hospital level and serving individuals in metropolitan statistical areas (MSAs), in the new scheduling system the patient scheduling function operates on entire populations resident in electronic statistical areas (ESAs). As discussed earlier, provider competition tied to aggregated, comparison, and trending ESA control metrics can then be used to create electronic marketplaces for OT/PT appointment bookings in a way that can very aggressively contain costs and drive inefficiencies out of OT/PT provider appointment setting workflows, in much the same way supply chains drive costs out of assembly plants.

4. **Separates OT/PT Patient Scheduling Logistics From The Daily Medical Functioning Of The Hospital.** By keeping the scheduling of the OT/PT patient separate from payment considerations, issues of eligibility, pre-existing conditions, and pre-authorization are avoided. The initial thinking is that access to care is the over-riding priority. In the absence of therapy, the medical issue can't resolve itself, and may get worse. The payment issue in contrast will always resolve itself. If it does not, there have been no out-of-pocket expenses, and the OT/PT's marginal cost for the provision of an
unpaid therapy session is small, and so recoverable by accrual within its negotiated bill rates. The extended thinking is that extricating the eligibility, pre-existing conditions, and pre-authorization roadblocks from the daily OT/PT facility workflow is the first step towards the complete removal of OT/PT patient scheduling considerations from the daily functioning of the OT/PT facility.

5. Enables Universal Access To OT/PT Care. In the new OT/PT patient scheduling system, the identification credentials presented by the patient's medical condition are used to identify ESA residence. Instead of controlling access to care at the individual level, where pricing is inelastic and the only means to cut costs is to deny access, the focus of control is on controlling the properties of a statistical cluster of medical conditions, in a space that is price elastic. Vendors bid on the administration and revenue to be had from ESA populations. There are no considerations of eligibility, pre-existing conditions, or pre-authorization (Cohn, 2007), or the need to negotiate re-imbursement rates for individual medical procedures (Pérez-Peña, 2007). The introduction of ESAs enables both universal access and cost containment. The payor bids on the medical condition and treatment plan at the statistical level. The patient is not an individual but simply a resident datapoint of a particular electronic statistical area. The healthcare provider negotiates to service patients within a given medical profile risk package of patient population outcomes provided by ESA brokers and payors. The healthcare provider files claims for payment based on having served a resident of an ESA with a particular medical presentation and outcome profile, and not based on the servicing of a specific patient.
6. **Enables Aggressive Cost Containment.** The current thinking driving the compensation for services and the containment of costs is micronetic, tied to arcane rules of individual patient eligibility, pre-existing condition, and pre-authorization, all as a means to justify patient exclusions and so compensate for the inelastic price nature of OT/PT services. Payment for OT/PT services is accordingly currently made based to an artisan-level payment eligibility model in which access to care and payment for services is produced from individual patient therapy sessions, pre-existing condition exclusions, and stepwise pre-authorizations. In the new approach, the old micronetic thinking is replaced by new form of macronetic thinking which offers electronic automation, scalability, and fully transparent performance metrics. The point is then, instead of operating at the level of individual patients, and so impinging on their price-inelastic need for medical care, the cost-containment is based entirely on aggregates, trends, institutional-level negotiations, and comparisons computed from transparent data handles, all of which do have price elasticity. These transparent data handles enable aggressive negotiations on aggregate levels and average rates and volumes even as the individual items that constitute the aggregates and averages, the OT/PT therapy sessions, remain price-inelastic commodities.

6.5 **A New Vision For OT/PT Patient Scheduling**

Queues have been formally studied for a long time, and have found wide scale application in electronic settings such as EDI-driven automotive parts supply chains and
the bid and ask queues of electronic stock, money, and commodities markets. Routers have similarly outgrown their origins in physical settings related to transportation and warehousing logistics, and have since been very successfully extended to electronic settings, from modern telephone switches to the routing of internet data packets and multimedia streams. Delivery is resolved by hardware lookups of pre-assigned names and decisions tied to timeouts, congestion, and hops. This study demonstrated it is desirable to put some of this thinking behind these queues and routers to good use in a new way of scheduling OT/PT appointments.

OT/PT patient referrals currently originate by an archaic method dating to the early 1980's. Paper referral forms are placed in physician practices throughout town. As potential OT/PT patients are identified, these forms are filled out and then faxed to the OT/PT service provider who provided the form. To reflect the current referral model, the OT/PT evaluation and treatment requests in this study are routed to a set of evaluation and treatment queues which are captive to a single medical provider.

There is however no reason why these medical appointment request queues should be processed in small numbers and be captive to a single healthcare provider. In fact, soon there will be a need for the selective and optimizing processing of entire new families of electronic medical appointment requests and appointment bookings, and in large volumes. These requests will come from HIPAA-style electronic health record portability and other large-scale eGovernment initiatives, and from the increasing computerization of medical records in hospitals and associated healthcare-related organizations. The electronic requests will quickly number in the hundreds of millions. Their nature and volume will require the invention of new types of electronic
datapackets, and new ways to route, queue, and otherwise process large volumes of these specialized datapackets.

The sources and sinks of these new datapackets will be patient avatar populations resident in Electronic Statistical Areas (ESAs). The patient avatars in the ESA share a medical condition presentation and outcome profile that is established by statistical means. The profile is defined from the case outcome histories of earlier patients who presented statistically similar primary diagnoses and presentation profiles, and had statistically similar medical outcomes. ESAs transform access to medical care in a way that provides universal access with built-in cost containment. In the ESA approach, you insure a medical profile against all possible claims within a population at large, instead of an individual patient against all possible medical conditions. There are no issues of individual patient eligibility or exclusion tied to employer group membership, pre-existing conditions, or pre-authorization considerations. Eligibility is established strictly by the presentation of medical identity credentials which document the patient's medical needs in terms of residency in a given ESA. Hospitals negotiate and contract with one or more ESA brokers for the payment of medical services, and the ESA brokers in turn clear payments with government and private payors. ESAs make universal medical access possible because they abstract medical conditions from individuals. The eligibility is established by the presentation of the identity credentials tied to the medical presentation and outcome profile of the patient, instead of by the presentation of the patient's identity credentials as an individual.

The payor can recruit electronic customers, based on ESA residence, instead of physical ones, based on the MSA serviced by a hospital. New classes of businesses
targeted at electronic healthcare customer aggregation will come into existence, and sell the aggregated electronic patient bundle as a block to the ESA brokers. The hospital gets the money from the ESA broker based on the terms of their contract negotiations. The ESA broker bills the government or another ESA owner, or yet collects money directly from their physical customers, depending on the personal identification presented by the patient. ESA brokers must take all comers at the price they set. There is no pre-existing condition, managed care, or eligibility question. The hospital and ESA broker negotiations pay based on outcomes documented by case histories. Hospitals are free to specialize and turn down or transfer ESA patients, but they must take all patients within a given ESA they choose to service, regardless of whether they present a private or government ID. A commodities market for OT/PT services, and stock issues by ESA brokers, incentivize their profitability and so helps reduce costs.

Contracts between healthcare providers, ESA brokers, and payors for the servicing of ESAs and ESA bundles the can be reviewed and re-negotiated often, initially on a quarterly or yearly basis, and soon, as other OT/PT practices throughout the country adopt the population-level automated OT/PT scheduling system described in this work. There is market pricing of ESAs and ESA bundles administered by the ESA brokers operating in OT/PT therapy commodity markets that look little different from wheat, pork or oil futures, or the marketing of unused pollution rights.

There are highly leveragable cost-containment handles by means of a long and detailed electronic audit trails data suitable for aggregation and drill-down reviews, what-if scenario management, and cross-environment comparisons of population clusters resident in every Electronic Statistical Area (ESA). There handles can be reviewed like
the financial profile and prospect of a company in the stock market, and so can also just as easily create markets for ESAs and ESA bundles. The macronetic view can be used very aggressively to contain costs and drive inefficiencies out of OT/PT provider workflows the same way supply chains drive costs out. These could include for example challenging a percentage of billables, random documentation reviews by external auditors, and benchmarked or trend-based comparative case history reviews.

The handling of the new types of electronic datapackets originating from ESA sources and sinks is very different from the functioning of the current thinking in electronic data packet queuing and routing. In the current thinking, the datapacket must have a sender, a recipient, and a payload. The new vision for the new types of datapackets foreshadowed by this study is one which outgrows the simple delivery-oriented and path-based routing intelligence of internet routers, and assumes in addition the price-oriented and distribution-based intelligence of an electronic supply chain.

6.6 Follow-Up Projects

The implementation of this new vision calls for new classes and families of electronic routers and electronic queues that can process thousands of OT/PT patient referrals at a time. These new routers and queues will serve as a marketplace clearinghouse for medical providers who compete to provide services to entire patient populations. These populations may well still largely reside physically within the geographic service area of the hospital, its MSA, but will derive their collective identity from electronic statistical areas (ESAs) generated by various eGovernment initiatives, the
establishment of ESA brokerages and associated new type of business families, the
electronic medical record portability and accountability sought by HIPAA, and the
increased computerization of healthcare providers.

The failure of scale in the sharing and tracking of electronic patient data is already
in the national news (Urbina and Nixon, 2007). There is an urgent need for research
funding for the development of new classes and families of electronic packet queues and
routers that can provide access to medical care to patient populations resident in
electronic statistical areas (ESAs).

In the absence of funding to advance large-scale patient scheduling automation,
medical care will not scale, medical costs will continue to escalate, and patients will
continue to suffer. Electronic records will be lost or otherwise not be properly forwarded.
There will be a break in the continuity of care and costly duplication of medical tests.
And OT/PT patients will continue to see delays in getting rehabilitation. All for simple
and avoidable reasons such as a failure "to assign specialists to centers with the biggest
backlogs" (Urbina and Nixon, 2007).

6.6.1 Project 1. A Demonstration Welcome Center And Care Center

One important observation from the Case Study was that the shop-floor workflow
of the OT/PT facility can be simplified by the creation of separate OT/PT physical areas:
a Patient Welcome Center, a Patient Care Center, a Therapist Center, and an
Administrative Center. With the new layout, the patient would gain greater access to
care with the help of a patient advocate and simplified scheduling, and the therapist would
be able to concentrate solely on their medical care. The patient and the patient's caretaker would be greeted by the Welcome Center patient facilitator. The patient facilitator would sit in an open pit, and greet and take the party to a designated area within the Care Center at the start of their appointment. The therapist would meet the patient in this area "chairside" like a dentist, and leave the party there at the end of the billable session. The facilitator would then return the party to the Welcome Center, and address any follow-up scheduling and billing issues as they depart. The Welcome Center would also have a kiosk to help the caretaker use a secured web-enabled interface to enter their scheduling preferences, and so avoid phone tree and phone-tag scheduling frustrations later.

Funding is needed to implement the Welcome Center concept at the OT/PT facility as a model demonstration project. The new layout, roles, and kiosk would combine modern dentist office patient flow practices, Wal-Mart-style retail customer greeting and store orientation, the automation and security of bank ATMs, and the convenience of self-service kiosks like those used at airports and car rental agencies. It would also provide the next steps in the transition of the OT/PT practice to the full version of the more abstracted and automated OT/PT patient scheduling vision presented in this study.

6.6.2 Project 2. A Location And Caretaker Preferences Survey

This study appears to be the first to explicitly consider the scheduling of OT/PT appointments at multiple locations, and to consider the needs of the OT/PT patient's caretakers explicitly and separately from the needs of the OT/PT patient. Funding is needed to explore the roles of multiple locations and designated caretakers in the access
to OT/PT care. The caretaker has the option to come to the hospital's main facility, or to pick a location nearer their home, work, or the patient's school they see as more convenient. The OT/PT personnel also noted that the caretakers have skewed weekday and time of day preferences, and are willing to wait very long times before committing to a therapy location, but could not provide specifics. How receptive would caretakers be to using a preferences capture web interface they could access from home or work, and which would free them from phone trees and phone tag? To what degree would the caretaker welcome mashup enhancements, for example track the resolution of a wheelchair funding requisition, or a location-based community plug-in showing soccer practice dates? Would they welcome a friendly Welcome center interaction with a patient facilitator and case advocate? What is their weekday, time, and location preference distribution, in what way is it skewed, and why? A study and survey is needed to document Welcome and Care Center time and motion improvements, and the preference distributions and un-met caretaker needs which are functioning as a barrier to OT/PT session scheduling, and high no-show, cancellation, and re-schedule rates. Currently the OT/PT hospital can only convert about 50% of the physician referrals into paid evaluations, and some 25% of treatment appointments are re-scheduled or abandoned. There are also long delays between the arrival of the referral, and the hosting of the follow-up evaluation and treatment sessions. A funded study is needed to establish the reasons for these discontinuities, and measure the extent to which the approach in this study would improve access to care on the part of OT/PT patients.
6.6.3 Project 3. A Large-Scale OT/PT Appointment Optimization Engine

As discussed in detail earlier, the simulation engine implemented in this study would benefit from many enhancements which are important to (a) demonstrate the scalability and optimization capabilities of the new automated OT/PT scheduling system; (b) enable the separation of the OT/PT scheduling function from the hospital's daily functioning; and (c) support patient streams and the assignment of payor channels and patient sources and sinks based on patient residency in Electronic Statistical Areas (ESA). Funding is needed to implement these enhancements. Multi-processor computers are needed to scale the automation of OT/PT therapy appointment scheduling to populations of tens of thousands of patients a week at hundreds of locations. Design man-hours and more advanced simulations are needed to help perfect the architecture, selectivity, and optimization capabilities of the automated 5-Queue Referral, Evaluation and Treatment OT/PT appointment scheduling engine described in this study.

6.6.4 Project 4. Automated OT/PT Scheduling Under Separation Of Duties

The patient scheduling solution for the OT/PT practice calls for the separation of the roles of the patients, caretakers, therapists, schedulers, payors and administrators documented in this study into abstracted OT/PT appointment requests and appointment bookings held in prioritized queues and processed by a rollover distribution engine polled at varying scheduling frequencies. The sources and sinks of these appointment requests and bookings originate form the preferences and actions of the stakeholders. In this study, the capture of these preferences and actions was simulated by number generators
and randomizers. Funding is needed for the actual implementation of these interfaces for use in pilot program at a national-scale OT/PT facility. The anticipated interfaces include the following:

(a) *Patient Capture Interface*. This interface is geared to the capture of the OT/PT patient's contact information, OT/PT specific medical profile, and appointment history.

(b) *Caretaker Preferences Interface*. A secured website dashboard that lets the 3,000-5,000 parents in their patient base view their child's therapy schedule from the comfort of their homes or work, store their preferences for weekdays, timeslots, and locations for sessions, and make requests to reschedule appointments. Value-added mash-up services like parking directions or validation, means to notify cancellations or request changes. Durable equipment grants. Tracks wheel-chair grant requests. A mashup example.

(c) *Referral Classifier Interface*. A secured website that lets the referral classifier assign an "OT" or "PT" label to the referral, based on a heuristic set of rules defined over the years in house, and also identify a subset pool of designated therapists with the appropriate "OT" or "PT" from a pre-defined grouping of therapists who have been designated as skillset specialists for a particular primary medical diagnosis implied by the nature of the referral.

(d) *Scheduling Facilitator Interface*. This interface is intended for use by the people facilitators and information communicators in the Welcome Center. This interface is informational. It indirectly coordinates the function of the other interfaces, and inspects the tuning status of the OT/PT scheduling engine. Has the patient OT/PT
profile and referral been properly captured? Has the caretaker supplied the necessary location, weekday, and daytime preferences? Have the latest therapist skillsets and locations identified? Has the therapist set the rollover flags for earlier appointments? What is this patient's OT/PT appointment history? When is this patient's next OT/PT appointment?

(e) Therapist Interface. This is a simple interface used to report the therapist's appointment rollover decision, and to communicate the hours the therapist is available for work, or absent because of illnesses, vacations, holidays, and meeting conflicts. Also presents the therapist's historical book of appointments, and their book of appointments for the next appointment cycle. This interface is completely independent of scheduling questions.

(f) Payor Interface. Provides an appointment history oriented to the description of medical profile appointment histories. This interface is not intended to support patient-centered questions. It is intended to support Electronic Statistical Area (ESA) residency brokering.

(g) Administrator Reporting Interface. For real-time information reporting based on aggregation, comparisons, trends, and what-if scenario management on issues related to patient service rates, therapist and location utilization, and other control metrics which show that the daily functioning of the OT/PT facility is serving its mission to provide medical care in an efficient and effective manner.
6.6.5 Project 5. Novel OT/PT Appointment Routers & Queue Processors

There has been as of yet no development of new classes of electronic routers and electronic queues specialized to the distribution, arbitration, and resolution of specialized electronic requests of the type handled by the medical appointment request and appointment booking queues described in this study. The current philosophy behind datapacket routing is grounded in terms of packet source, destination, and payload. Funding is needed to investigate new classes of electronic routers and queues specialized for the processing of the OT/PT appointment request and appointment booking queues introduced in this study in a way that will support the scheduling of large numbers of OT/PT patients who are being provided access to medical care based on their residency in an Electronic Statistical Area (ESA). In the ESA approach, you insure the a medical condition profile against all possible claims within a population at large, instead of an individual patient against all possible medical condition profiles. These new routers and queues transcend the simple sender, recipient, payload model of traditional datapackets because the intended receiver is not initially known, and it is not the delivery but the resolution and re-distribution of the request based on an event outcome that is important. Funding is needed to define the properties and implement the functioning of these new types of electronic queues and routers.
References


Bailey NTJ (1952) "A Study Of Queues And Appointment Systems In Hospital Out-Patient Departments, With Special Reference To Waiting-Times," *Journal Of The Royal Statistical Society*, 14:2, pp. 185-199.


Welch JD, and Bailey NTJ (1952) "Appointment Systems In Hospital Outpatient Departments," *The Lancet*, 1, pp. 1105-1108.


Appendix A. Case Study Questionnaire

A questionnaire was used to obtain initial values for the experimental software simulations. The values were provided by the supervisory staff of the OT/PT facility in the case study, and were current as of the end of January, 2007.

The values and comments in square brackets are consensus estimates provided by the supervisory staff based on educated guesses from years of experience and some consultation to internal datasets. "Most of this we do not measure because the range is quite variable, or it is very time intensive to measure."

1. Total number of OT+PT therapists, all locations: ___[121]___

<table>
<thead>
<tr>
<th>Location</th>
<th>OTs</th>
<th>PTs</th>
<th>OTs + PTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>main</td>
<td>25 (21%)</td>
<td>27 (22%)</td>
<td>52 (43%)</td>
</tr>
<tr>
<td>satellite</td>
<td>28 (23%)</td>
<td>41 (34%)</td>
<td>69 (57%)</td>
</tr>
<tr>
<td>2</td>
<td>6</td>
<td>11</td>
<td>17</td>
</tr>
<tr>
<td>3</td>
<td>5</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>4</td>
<td>3</td>
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<tr>
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<td>5</td>
<td>5</td>
</tr>
<tr>
<td>10</td>
<td>2</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>53 (44%)</td>
<td>68 (56%)</td>
<td>121 (100%)</td>
</tr>
</tbody>
</table>

2. Total number of OT+PT therapists at main hospital's location: ___[52]___
3. Total number of OT+PT therapists at secondary locations (45): __[69]__

4. Percentage of total therapists who are OTs: __[44%]__

5. Percentage of total therapists who are PTs: __[56%]__

6. Rough number of supported primary diagnoses: __[100]__

    of which (est.):
    number that are OT primary diagnoses: __[no answer]__
    number that are PT primary diagnoses: __[no answer]__

7. Rough number of OT primary diagnoses an OT therapist specializes in: __[20]__

8. Rough number of PT primary diagnoses a PT therapist specializes in: __[20]__

9. Average daily number of new patient referrals received requesting a new patient eval, Mon-Fri 8-5: __"30-40 per day, but in the past when we measured this /.../ 50% never complete the eval"__

10. Maximum number of evals+eval reports a therapist is expected to host+write per week: __[3-10]__, with __[1]__ in a "slow" week, and __[20]__ in a "busy" week. __"this varies greatly, ortho pt's /orthopedic physical therapists/ could do as many as 15-20 evals a week"__

11. Maximum number of 1-hour treatment sessions a therapist is expected to host per week: __[25-30]__, with __[25]__ in a "slow" week, and __[35]__ in a "busy" week.

12. Billable time credit for each eval+evalReport a therapist hosts: __[1 hour (4x15 units)]__ __"therapists are only permitted to bill for face-time, only the time with the patient, with rare exceptions"__

13. Billable time credit for each treatment session a therapist hosts: __[1 hour for 4 billable units (60 minutes)]__ __"each 15 is one billable unit"__

14. Target number of billable hours a therapist is expected to have, per week: __[65%]__ __"65% of hours available for work"__

15. Average number of treatment sessions generated by each new patient eval: __[6]__, with a common mode range from __[0]__ to __[150 (3x per week for a year)]__. __"varies tremendously, impossible to know"__

16. Percentage of treatment sessions that are schedule EOW (every other week): __[15%]__. __"guess only"__
17. Average number of weekday+time slot options a patient is willing to consider for a given location: ___[4]___, with a common range from ___[1]___ to ___[6]___. ["Guess only. Often patients are very specific wrt time, day and location."

18. Average number of days a patient is willing to wait if the wait lets them have their OT/PT eval or treatment sessions at their preferred (non-main) location closer to home/work/school: ___[30-200]___ (as opposed to being able to come sooner, but have to travel to the more distant main hospital's location). ["6 months for non-urgent conditions, some more"]
Appendix B. Holidays Considered

The house holidays listed in the tables below were not used for scheduling. The ability to skip scheduling patients on holidays were an important concern of the hospital therapists and schedulers, who noted the exception driven nature of the scheduling when scheduling week-over-week appointment series. The OT/PT patient scheduling software was accordingly implemented to use ISO-8601 based calendaring and the capability to read an exclusion properties file containing the house holidays. The "real-date" calendar and exclusion file made it possible not to schedule OT/PT appointments on designated OT/PT facility holidays. The software was also written so as adjust the workload computations for weeks containing holidays, and schedule roll-over appointments that fell on holidays at the earliest possible next opportunity, all in automated fashion.

Holidays For The Year 2007

<table>
<thead>
<tr>
<th>Date</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mon-2007-01-01</td>
<td>New Year's Day</td>
</tr>
<tr>
<td>Mon-2007-01-15</td>
<td>Martin Luther King Day</td>
</tr>
<tr>
<td>Mon-2007-02-19</td>
<td>President's Day</td>
</tr>
<tr>
<td>Mon-2007-05-28</td>
<td>Memorial Day</td>
</tr>
<tr>
<td>Mon-2007-07-04</td>
<td>Independence Day</td>
</tr>
<tr>
<td>Mon-2007-09-03</td>
<td>Labor Day</td>
</tr>
<tr>
<td>Mon-2007-10-08</td>
<td>Columbus Day</td>
</tr>
<tr>
<td>Mon-2007-11-11</td>
<td>Veteran's Day</td>
</tr>
<tr>
<td>Thu-2007-11-22</td>
<td>Thanksgiving Day</td>
</tr>
<tr>
<td>Fri-2007-11-23</td>
<td>Day After Thanksgiving Day</td>
</tr>
<tr>
<td>Mon-2007-12-24</td>
<td>Day Before Christmas Day</td>
</tr>
<tr>
<td>Tue 2007-12-25</td>
<td>Christmas Day</td>
</tr>
<tr>
<td>Mon-2007-12-31</td>
<td>Day Before New Year's Day</td>
</tr>
</tbody>
</table>
### Holidays For The Year 2008

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</thead>
<tbody>
<tr>
<td>Tue-2008-01-01</td>
<td>New Year's Day</td>
</tr>
<tr>
<td>Mon-2008-01-23</td>
<td>Martin Luther King Day</td>
</tr>
<tr>
<td>Mon-2008-02-18</td>
<td>President's Day</td>
</tr>
<tr>
<td>Mon-2008-05-26</td>
<td>Memorial Day</td>
</tr>
<tr>
<td>Mon-2008-07-04</td>
<td>Independence Day</td>
</tr>
<tr>
<td>Mon-2008-09-01</td>
<td>Labor Day</td>
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<tr>
<td>Mon-2008-10-13</td>
<td>Columbus Day</td>
</tr>
<tr>
<td>Mon-2008-11-10</td>
<td>Day Before Veterans Day</td>
</tr>
<tr>
<td>Tue-2008-11-11</td>
<td>Veteran's Day</td>
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<tr>
<td>Thu-2008-11-27</td>
<td>Thanksgiving Day</td>
</tr>
<tr>
<td>Fri-2008-11-28</td>
<td>Day After Thanksgiving Day</td>
</tr>
<tr>
<td>Thu-2008-12-25</td>
<td>Christmas Day</td>
</tr>
<tr>
<td>Fri-2008-12-26</td>
<td>Day After Christmas Day</td>
</tr>
</tbody>
</table>

### Holidays For The Year 2009

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<th>Date</th>
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<tr>
<td>Thu-2009-01-01</td>
<td>New Year's Day</td>
</tr>
<tr>
<td>Fri-2009-01-02</td>
<td>Day After New Year's Day</td>
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<td>Mon-2009-01-19</td>
<td>Martin Luther King Day</td>
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<td>Mon-2009-02-16</td>
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<td>Mon-2009-05-25</td>
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<td>Fri-2009-11-27</td>
<td>Day After Thanksgiving Day</td>
</tr>
<tr>
<td>Fri-2009-12-25</td>
<td>Christmas Day</td>
</tr>
</tbody>
</table>
Appendix C. Data Reports Generated

The new OT/PT patient scheduling system software implementation generated 13 data reports, as described below. The data from these reports was used in the analysis of the data obtained from the simulations.

1. *Locations Report:* (*_locations.report) Lists the 10+ OT/PT locations supported by the hospital's OT/PT division, the medical specialties supported at each location, and the therapists assigned to each location.

2. *Medical Specialties Report:* (*_medConditions.report) Lists the locations and the therapists at that location capable of supporting a given medical condition / primary diagnosis / specialty.

3. *Patients Report:* (*_patients.report) Lists the patients hosted by the OT/PT Facility, and their primary diagnosis, preferred location, and preferred weekday and time slot scheduling preferences. Importantly, this report also lists the delay in days from the time a new patient is first referred to the hospital for an evaluation, and the day the evaluation is scheduled. Similarly, this report also lists the delay in days from the time a patient is evaluated, and the first treatment session in a series was booked.

4. *Therapists Report:* (*_therapists.report) Lists the available therapists, their designated location, designation (OT or PT), and medical specialties, and all their appointments, in chronological order.


6. *Eval Appt Report:* (*_apptEvals.report) Lists all evaluation (referral) requests, date-stamped by their Poisson arrival times, and the date of the eval scheduled to service the request. This report cross-checks the data in the other reports, and shows the number of days elapsed between the arrival of a referral, and the scheduling of the eval for this referral.
7. **Eval Backlog Report**: (*_apptEvalsBacklog.report) Shows the eval requests (referrals) that could not be booked because no available therapist could be identified.

8. **Treatment Appt Report**: (*_apptTreats.report) Lists all treatment series generated at the end of the day after a given evaluation session was held. Cross-checks other reports, and shows the fate of a given eval session, and the workload scheduling echo each eval generates.

9. **Treat Backlog Report**: (*_apptTreatsBacklog.report) Shows the treatments that could not be booked because no available therapist could be identified. These backlogged treatments arise for example after evals are held and the first treatment must be scheduled, or when a no-show must be re-scheduled.

10. **Schedule By Location Report**: (*_scheduleByLocation.report) Shows the capacity utilization for each of the 10+ OT/PT main and satellite locations, in percent of available billable hours. Lists all evals and treatments hosted at a given location, with therapist and patient details, broken down and totaled by week.

11. **Schedule By Patient Report**: (*_scheduleByPatient.report) Shows each patient's scheduled appointments, in chronological order, from eval through the last treatment session.

12. **Schedule By Week Report**: (*_scheduleByWeek.report) The book of appointments. Shows a chronological lists of all appointments scheduled by the scheduler, grouped by week.

13. **Schedule By Therapist Report**: (*_scheduleByTherapist.report) Shows the work schedule of evals and treatments for each therapist, broken down by week. Lists each therapist's scheduled eval and treatment sessions chronologically, by weekday and time, and then totaled by week, including the number of evals hosted that week, the number of treatment sessions held that week, and the resulting computed billable time workload for each week (for example 45%, or 63%, or 70%).