

# Modified Waveform Based Queuing Model for Patient Scheduling

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**Abstract-** A structured appointment scheduling system can go a long way toward improving revenue preventing provider and staff “burn out” and increasing patient satisfaction in medical practice. The modified wave approach for scheduling patients is an alternative to the steady stream and the pure wave methods. Modified waveform approach works best to large hospitals where there is heavy patient in flow. With this approach, more than one patient is scheduled at the beginning of each hour and the end of the hour is left open, enabling the provider to catch up, if necessary. This paper proposes a simplified queuing model based on modified waveform approach for patient scheduling which will increase patient satisfaction, which in turn will increase profit.

**Keywords:** Modified Waveform, Schedule, Model

## I. INTRODUCTION

Scheduling appointments correctly and efficiently is crucial to the smooth operation of the medical office. There are several factors that must be taken into consideration when scheduling appointments. The patient who has made an appointment weeks or even months in advance wants to be seen within 15 to 20 minutes at the time of arrival. The physician wants a smooth flow of patients during the time scheduled for seeing patients. Patients who are ill or have accidents want to be able to see their physician on the day of the illness or injury. They prefer to be given a specific time, even if it is later in the day, rather than come into the office and wait for an open moment.[1]

Successfully planning and managing patient flow is one of the most challenging aspects of practice management. The most important criteria the medical assistant must take into consideration when scheduling appointments are exhibiting good interpersonal skills and reducing the amount of time a patient has to wait to see the physician. Doing this using the modified wave technique will increase both patient and staff satisfaction with less overhead. Losing patients due to long waits and losing staff due to “burn out” are very costly. Use of the modified wave methodology can positively impact both of these.

In a modified wave system, patient appointments overlap so that when one patient is late arriving or a visit finishes early, another patient is waiting to be seen by the physician. Patient appointments also are clustered to create heavier volume at the beginning of the hour and at the beginning of each clinical session. Initial overlapping (or double booking) of appointments tapers off toward the end of each hour; thus any backlog of patients is relieved before the next wave starts. Ideally, a constant flow of patient’s smooths out any imbalances in the lengths of visits, but no patient is delayed by more than a few minutes beyond the scheduled appointment time. Physicians see more patients in a day, and patients face fewer frustrating waits. [2]

Modified wave scheduling is an alternative to fixed-wave scheduling—where several patients are scheduled to arrive simultaneously, regardless of their symptoms or conditions. They are then seen on a first-come, first-served basis. Patients at the end of the queue tend to experience long delays while physicians and staff has to work under the constant stress .Patient satisfaction and office morale are compromised in scheduling the optimum number of patients per day.

The objectives of any modern scheduling system are to:

- Provide patients (who want them)with same-day appointments to ensure high patient satisfaction with access and low no-show rates
- Improve continuity of service by eliminating urgent care and walk-in
- Improve productivity via more reliable and steady flow of patients
- Reduce no-show rates

## II. DESIGN CONSIDERATIONS

Designing a flow for appointments without consideration of the patients' needs will result in poor patient satisfaction. This can be solved by a schedule that works for the needs of patients. To obtain a flexible scheduling system

1. Recognize what are the "running parts" needed out of the day:[4]
  - a) For the patients, the perfect schedule is getting an appointment when they want to be seen.
  - b) For the physicians, the perfect schedule is consistent — without gaps and down time.
  - c) For the nurses and medical assistants, the perfect schedule is one that starts on time and flows smoothly.

A perfect day can be obtained with a flexible schedule. . Basically, divide up the day into equal blocks. To do that, start with the first appointment time for patients. Staff and providers should arrive in advance of that time. How far in advance will be determined by the type of practice and what need to get done before patients start arriving.

2. Determine how long it takes to see a new patient and how long it takes for a follow-up patient. Generally a new patient visit takes about twice as long as an established patient visit requires. If tests or procedures, has to be done determine how long those take, too. Thus classify visit types into three:[2]
  - a) Short Visit for follow-up patient
  - b) Medium visit for new patient
  - c) Long for tests or procedures

Template for a flexible schedule contains - a start time, an end time, and a minimal appointment time. Divide the day into blocks of length using multiples of shortest type of visit. Many practices use 10 minutes as the minimal slot. But focus should be to make the system realistic. To do so schedule patients for the time of day they want to be seen and assign them the amount of time (one 15-minute slot, two 15-minute slots,etc) based on the type of care they will need (new patient visit, established patient follow-up, established patient new problem, procedure, etc.).

The scheduling system can be simple if it is patient-centered. This paper focuses on proposing a simplified queuing model, by reducing all the visit type as "patient visit". So there are no slots called "physicals" or "immunizations" or anything else other than "patient visit".[5]

Patient scheduling techniques can correct some problems, but can't correct all. Listed below are a number of patient flow problems that generally affect the scheduling system. If these problems are not addressed, these problems can disrupt patient flow, physician productivity and even the best patient scheduling schemes. The problems that affect Scheduling System are:-[2]

1. **No shows:**-Clear policies have to be formulated to handle those patients who fail to cancel appointments at least 24 hours in advance.
2. **Late arrivals:**-There should be some good policies to take care of patients who will arrive late than the scheduled time. Any late patient arriving should be worked in only at the convenience of other patients such that no other patient should be delayed because of the late patient.
3. **Walk-ins:**-There are some cases that must be seen immediately. That case has to be scheduled without disrupting the normal schedule.
4. **Patients with extra problems:**-Some patients maybe scheduled for one problem, but can come in with more, can put physician behind schedule. So additional time has to be allotted without making others suffering.

## III. PROPOSED SIMPLIFIED QUEUING MODEL

Queuing is the process of moving patients in a specific sequence to a specific service according to the patients need. The term scheduling stands for the process of computing a schedule. This may be done by a queuing based scheduler [6]. Consider a clinic where patients call to make appointments for a visit in the future or some time during the day of the call. Given the current appointment schedule, the administrative staff schedules each incoming request for an appropriate day and updates the schedule accordingly. The appointment delay for a patient is the time between the day the patient requests an appointment and the actual appointment date. The appointment delay for a patient is zero if the appointment is scheduled on the same day the patient calls.

There are many ways for appointment scheduling, but deciding the right one is very difficult. So for reducing the complexity of appointment scheduling a simplified queuing model can be used as template and necessary

changes can be done according to the provider. Queue represents a certain number of customers waiting for service. The capacity of a queue is either limited or unlimited. The service is an activity requested by a patient, where each service takes a specific time. The scheduling algorithm is used to order the patients and to choose the next patient from the queue[6]. So for designing a simplified queuing model the following scheduling algorithms are used

1. Priority
2. Non pre-emptive Multi level Queue

In this paper it is assumed that all patients needs similar priority,so non pre-emptive multilevel queue scheduling policy is used with same priority at all levels. In this non pre-emptive multilevel queue scheduling there are three levels with each level maintaining separate queue. At each level service is done in FCFS manner. The following are the different levels. Level 2 will be for short type, level 1 for medium type and level 0 for Long type.

A non pre-emptive multi level queue model can be shown as follows:-

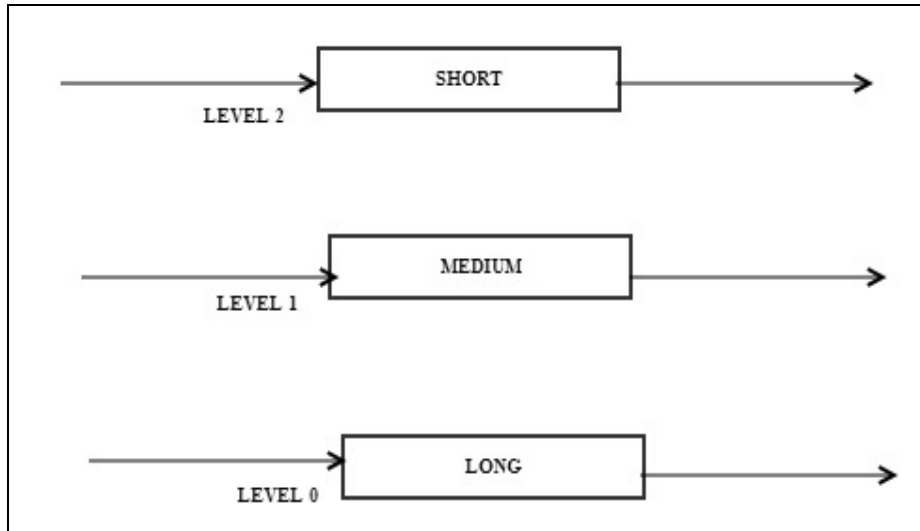


Figure 1 Multi Level Queue

The following digrams shows different levels of DFDs for simplified queuing model:-

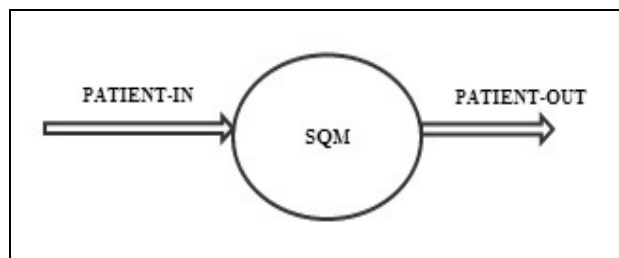


Figure 2 Level 0 Dfd

Figure 2 shows level 0 Dfd for Simplified Queuing Model which shows patient interaction with the scheduling system.

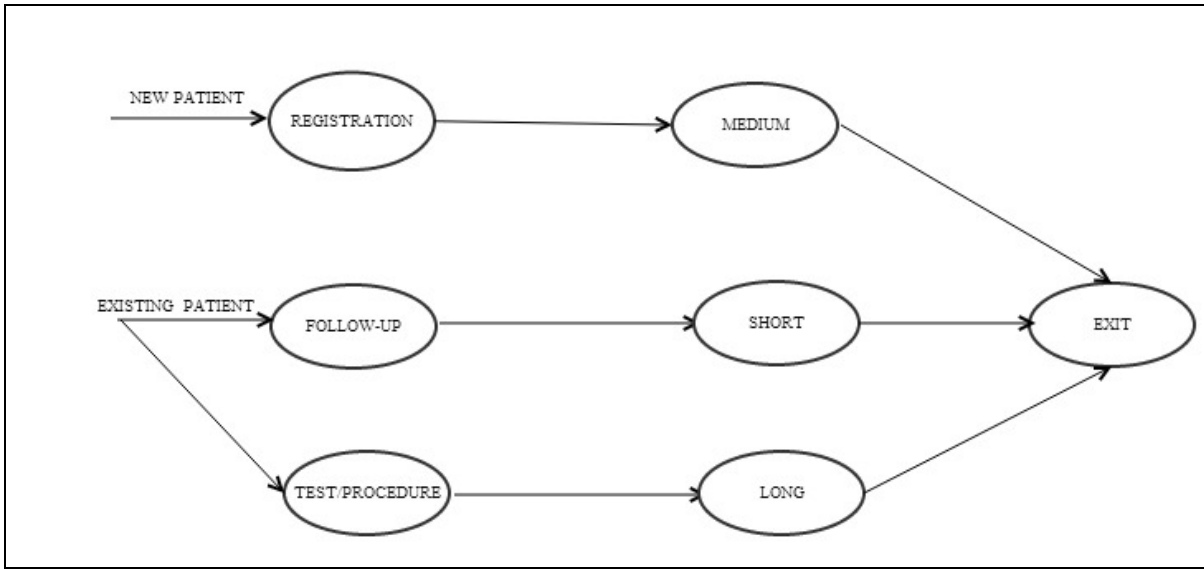


Figure 3 Level 1 Dfd

The fig-3 shows the diagrammatic view of classification of visit types as short ,medium and long based on the type of visit of patient.

If modified waveform approach is used for scheduling patients, the provider is allotted with more than one patient at the beginning of each hour and end of the hour is left opened. The advantage of keeping the end hour opened are:-




1. In case of emergency condition the provider can attend it
2. Some times the time actually taken by the patient can be more than allotted time. In that case provider can continue with that case without affecting the normal schedule
3. If any walk-ins are there, that can be handled without disturbing others
4. The provider can attend any pharmacist if required

In this model proper mixing of short, medium, Long is very important, since the mixing determines proper scheduling. This can be done in anyway. But it has to be done in such a way that the waiting time for the patients is less and provider is comfortable with the way scheduling is going. A sample time allocation table for a single provider in the morning session is shown below. According to this sample analysis, within 1 hour a single provider can give service to 4 patients. Like that within 4 hour 12 patients can be serviced.

Table1 Relationship between Waiting time and Allotted time

PATIENT	ALLOTTED TIME	WAITING TIME(IN SECONDS)
A	09:00	0
B	09:00	15
C	09:15	15
D	09:30	15
E	No arrival	—
F	10:00	0
G	10:15	0
H	10:30	0
I	11:00	0
J	11:00	15
K	11:15	15
L	11:15	15

Table2 Time allocation according to visit type

<div style="display: flex; justify-content: space-around; align-items: center;"> <div style="text-align: center;">  SHORT                 </div> <div style="text-align: center;">  MEDIUM                 </div> <div style="text-align: center;">  LONG                 </div> </div>													
<b>MORNING SESSION- 1 PROVIDER</b>													
Patient	09:00	09:15	09:30	09:45	10:00	10:15	10:30	10:45	11:00	11:15	11:30	11:45	12:00
A													
B													
C													
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The above table shows how patients are allotted according to the visit type. There are three possible outcomes for each appointment made. The patient may show up for her appointment, cancel her appointment on or before the day of the appointment, or she may not cancel but simply not show up for her appointment. Any of the above 3 outcomes has to be scheduled with proper care so that those who show up shouldn't be delayed. In this model 3<sup>rd</sup> outcome can be handled appropriately.

IV CONCLUSION

A simplified queuing model using modified waveform approach can improve the patient experience by properly scheduling the appointment time. The time slots are given in such a way that when one patient is arriving late or a visit finishes early, another patient is waiting to be seen by the physician. This can be done by overlapping the patient appointments in proper way. In this model more than one patient is scheduled at the beginning of each hour and the end of the hour is left open, enabling the physician to catch up, if necessary.

V FUTURE WORK

This simplified queuing model can be made ideal queuing model for patient scheduling by considering different patient types with case study. If different patient types are considered, then priority with multilevel feedback queue scheduling policy can be used.

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