

# Designing an appointment system for an outpatient department

**ChalitaPanaviwat<sup>1</sup>, Haruetai Lohasiriwat<sup>1\*</sup>, and Wipawee Tharmmaphornphilas<sup>1</sup>**

<sup>1</sup>Department of Industrial Engineering, Faculty of Engineering, Chulalongkorn University, Bangkok, Thailand. 10330

**Abstract.** An outpatient department in which non-urgent patients arrived for consultation faces with the problem of patients' long waiting time. Lack of an effective appointment is considered as the cause. In this study, a discrete event simulation model was developed to evaluate an appointment system. The developed system considered appointment rule, sequencing rule and environmental factor (priority rule). Various appointment systems were examined by the simulation model. All proposed alternatives effectively reduced outpatient waiting time without adding extra resources. With the introduction of appointment system, simulation had shown that average waiting time could be reduced thirty-seven to forth-four percent as compared to the current status. The most effective appointment system was finally recommended to the outpatient department for implementation.

**Keywords:** Appointment System, Waiting Time, Outpatient Department, Simulation

## 1. Introduction

Outpatient department is a main healthcare service for non-urgent patients. Many hospitals have a common problem of long waiting time in this particular department. The patients' survey we conducted also showed that long waiting time is their most often encountered problem. It is also a major cause of patient dissatisfaction in outpatient department's service [1] particularly that the usual service time is only few minutes with doctor consultation. Through our observation and interviewing at a hospital in Thailand, we found a number of patients arrive in awfully early morning (i.e., 4.00am until 8:30am). They expect to get queue for doctor consultation at the earliest possible. Their normal understanding is that the earlier come, the faster finish. This attitude results in congestion at the outpatient service long before the service hour even starts. Unfortunately, with the attempt to overcome this problem, the hospital manages by introducing an earlier nurse schedule. Nurses at triage eventually have to work before their official working time. According to Soriano A [2], long waiting time in outpatient services is dispensable. Establishing appropriate appointment system is one solution to this problem. Basically, appointment system can better align patient arrival patterns to the doctors' and nurses' actual services rather than the vice versa.

An appointment system consists of appointment rules and sequencing rules. Appointment rules include appointment interval (the length of appointment slot), block size (the number of patients in each appointment slot) and initial block (the number of patients in the first block of appointment system). These three factors differentiate types of appointment rules such as a single block system, an individual block system and a multiple block system. The single block system appoints all patients by

\* Corresponding Author: Haruetai Lohasiriwat, Email: haruetai.l@chula.ac.th



date, which all patients are assigned to the same time period. This appointment makes a long waiting time but many outpatient departments still use [3]. The individual block/ fixed interval system gives a specific time with equal interval for each patient [4]. The individual block/ fixed interval with an initial block system is the same as the individual block but more than one patient in the first slot. For example, Bailey's rule suggests placing two patients in the beginning of the session [5]. The multiple block/ fixed interval is similar to the individual block. However, the multiple block assigns more than one patient to each slot. For sequencing rules, there are many policies such as FCFA (no sequencing rule), RTBG (service return patients first then follow by new patients) and ALTER (alternating pattern between new and return patients). Cayirli [6] found that RTBG and ALTER were the best sequencing rules tested. With various type of appointment system available, it should consider environmental factors (e.g., priority rules, punctuality of patient arrival, no-show rate and resource-sharing) before implementing an appointment system. A priority rule is an ordering queue for serving patients in each appointment block such as FCFS (first-come, first-served) and serving appointment patients firstly.

Many researches from the earlier studies considering an appointment system only at the appointment rules and finding includes number of appointment patients in each appointment slot and the length of appointment interval. Yeon [7] identified that an appointment system for multiple doctors is not the best appointment system for an individual doctor. A hospital in Japan assigning two patients to a block and doubling up consultation's service time per interval, reduction of patients waiting time is also found [8]. On the contrary, our study additionally analyzes sequencing rules and priority rules together with the appointment rules to examine effects on the overall patients' waiting time. Our main objective is to develop a detailed appointment system for the case study hospital that could reduce patient waiting time without adding extra resource(s).

## 2. Model

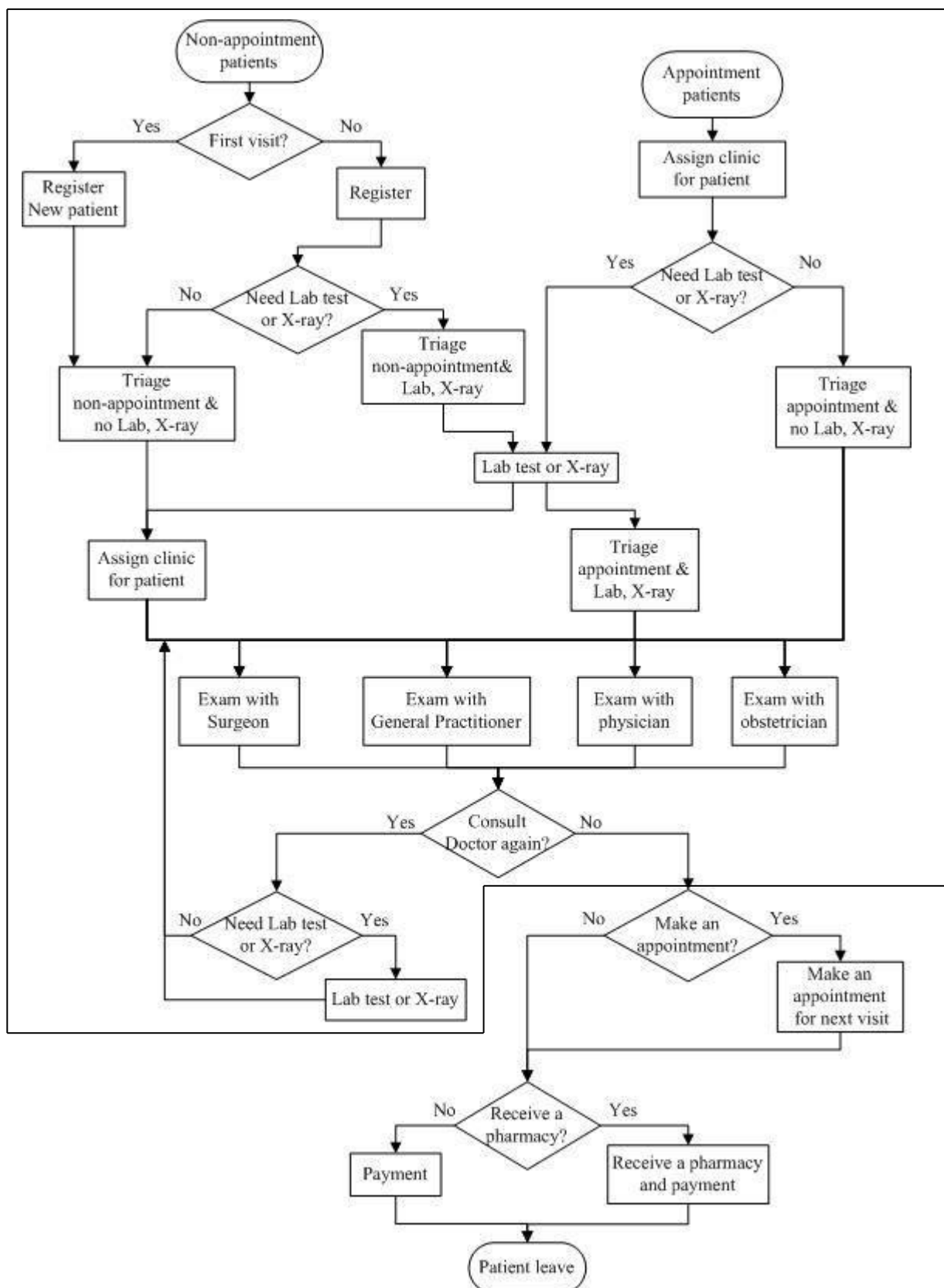
### 2.1. Description of an outpatient department

The outpatient department in this study has four clinics which are surgery, general practice, medicine and obstetric. The four clinics share common resources including nurses and laboratory test. This outpatient department operates with two types of patients: appointment (A) and non-appointment patients (NA). Non-appointment patients include new patients who first arrive at the hospital, walk-in patients and no-show patients who missed their appointments.

Patient flow of the outpatient department is shown in figure1. All appointment patients must go to a reception deck to identify the appointed clinic and check if there is any laboratory test required. Patients who need laboratory tests can go directly for the test and later come back for triage before doctor consultation. Otherwise, patients go for triage and follow by consultation. All non-appointment patients, on the other hand, need to pass registration process. Next step is screening by nurses to assign for the doctor clinic. In case of laboratory tests required, patients go for testing before consultation similar to the appointed group. After triage, all patients are queued for consultation. Then, according to doctor's recommendation, some patients could need additional laboratory tests or may be referred to other specialists. These patient groups usually assigned to come back to the same consulted doctor. After all consultation processes completed, patients may make an appointment for the next visit and get drugs from a pharmacy before leaving the hospital. These last two services are out of our scope.

### 2.2. Performance Measure

The objective of this study is to reduce patients' waiting time in the outpatient department by developing an appointment system that matching with doctors' and nurses' services available.



**Figure 1.** Patient flow diagram (scope of the study is shown within the designated line)

The performance measure to evaluate appointment system is a weighted average waiting time (WAWT). This measure is calculated using equation (1).

$$WAWT = \frac{(AWTA \cdot NA) + (AWTNA \cdot NNA)}{NA + NNA} \quad (1)$$

Where AWTA=Average waiting time for appointment patients, NA=Number of appointment patients, AWTNA=Average waiting time for non-appointment patients, NNA=Number of non-appointment patients

### 2.3. Data Collection and Simulation Model

The outpatient department opens Monday to Friday from 7:00 am until last patient leaves the department. However, the consultation hours are 9:00-12:00 am only. The research team manually tracks the actual time patient arrived and left each service station for a week. Patient arrival patterns from Monday to Thursday are similar, but Friday is different since surgery clinic is closed. Therefore, data used in this version of a simulation model is the one collected from Monday to Thursday period.

We studied 4 clinics (surgery, general practice, medicine, and obstetric) which are in the same building area. There is a doctor per clinic from Monday to Thursday. Four nurses work mainly in triage and two staffs work in registration. These are common resources for all clinics. All human resources involved in the outpatient department are shown in table 1.

**Table 1.** Resource of doctors and nurses.

Resource	Number
Registration	2 staffs
Triage for appointment	2 nurses
Triage for non-appointment	2 nurses
Surgeon	1 doctor
General practitioner	1 doctor
Physician	1 doctor
Obstetrician	1 doctor

Inter arrival time for appointment and non-appointment patients are shown in table 2. Service times were additionally collected between May 27-28<sup>th</sup> and June 5-7<sup>th</sup>, 2013. Approximately 400 patients were observed. The summary of service times are shown in table 3.

**Table 2.** Inter arrival time for patients.

Patient Category	Arrival time for patients	Inter Arrival Time (seconds)
Appointment patients	07:00-8:00 am	47 + EXPO(139)
	08:00-9:00 am	50 + EXPO(267)
	09:00-10:00 am	30+EXPO(508)
	10:00-12:00 am	315 + EXPO(280)
Non-appointment patients	07:00-8:00 am	179 + EXPO(253)
	08:00-9:00 am	51 + EXPO(161)
	09:00-10:00 am	2 + EXPO(253)
	10:00-12:00 am	177 + EXPO(328)

A simulation model for the outpatient department was developed using the ARENA Software version 14.0. In our observation, triages and consultation room were the most congested units. Therefore, the model is focused only from patient arrival until consultation is completed and included all pertinent resources.

**Table 3.** Service time in each unit.

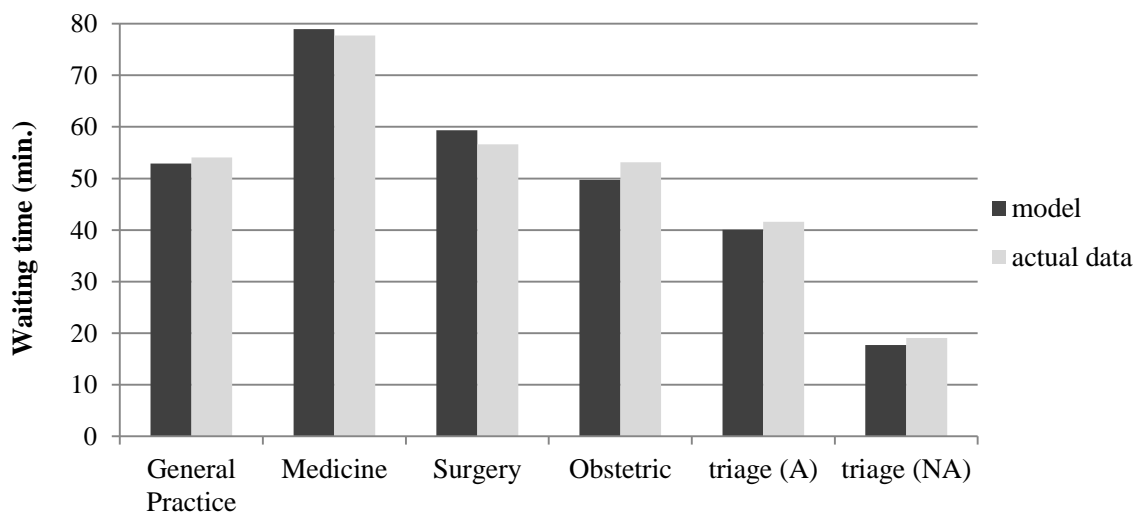
Service time	Time (seconds)
Registration for new patient	300 (constant)
Registration	180 (constant)
Triage for appointment and lab test patient	$100 + \text{EXPO}(109)$
Triage for appointment patient	$100 + \text{WEIB}(88.2, 1.05)$
Triage for non-appointment and lab test patient	$110 + \text{WEIB}(134, 0.569)$
Triage for non-appointment patient	$151 + \text{GAMM}(66.6, 1.23)$
Surgeon's consultation time	$85 + \text{WEIB}(136, 0.882)$
General practitioner's consultation time	$78 + \text{WEIB}(179, 1.11)$
Physician's consultation time	$120 + \text{EXPO}(120)$
Obstetrician's consultation time	$123 + \text{WEIB}(371, 0.601)$
Lab test- 1 <sup>st</sup> time <sup>a</sup>	$890 + 9.07\text{e}+3\text{BETA}(0.853, 1.27)$
Lab test- 2 <sup>nd</sup> time	$795+4.65\text{e}+3\text{BETA}(0.74,1.25)$

<sup>a</sup> Waiting time is included in the service time of this unit

EXPO=Exponential, GAMM=Gamma, WEIB=Weibull

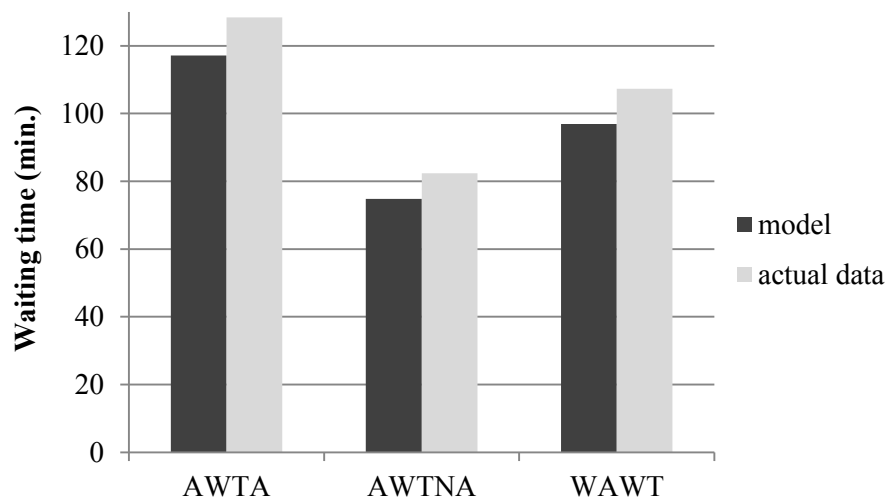
#### 2.4. Verification and validation of the model

Model verification and validation were performed. Figure 3 shows waiting time comparison between actual data and results from running 30 replicates of the model. Results from t-tests show that waiting time for each unit in model and actual data are not significantly different at the 95% confidence interval.



**Figure 3.** Waiting time for each unit from model and actual data.

Figure 4 shows comparison of weighted average waiting times. In this study, average waiting time for appointment patients is about 40% more than non-appointment patients. Results from t-tests show that AWTa, AWTNA and WAWT (weighted average of waiting time) calculated from the model and the actual data are not significantly different at the 95% confidence interval. From the statistical point, the simulation model hence can be used to simulate the real setting.



**Figure 4.** Weighted average waiting time.

### 3. Experiment

We study appointment systems by evaluating appointment interval, block size, sequencing rules, and priority rules. We experiment 30 and 60 minutes interval which come from surveying patients' preferences via direct interview. The block size for each clinic is calculated using an average consultation time. In an appointment, appointment patients can classify to patients who have a laboratory test and no laboratory test. A sequencing rule in this study is to order appointment patients who have a laboratory test in each clinic first then follow by appointment patients who have no laboratory test. Two priorities, first-come first-served (FCFS) and serving appointment patient first then non-appointment patient, are tested. In conclusion, there are four alternative scenarios in the experiment as listed below.

Alternative 1: 30 minutes interval. The numbers of patients in each block for surgery, medicine, general practice, medicine, and obstetric are 4, 4, 2, and 1 respectively. FCFS priority rule is tested.

Alternative 2: 30 minutes interval. The numbers of patients in each block for surgery, medicine, general practice, medicine, and obstetric are 4, 4, 2, and 1 respectively. Priority, serving appointment patients firstly, is tested.

Alternative 3: 60 minutes interval. The numbers of patients in each block for surgery, medicine, general practice, medicine, and obstetric are 7, 7, 4, and 1 respectively. FCFS priority rule is tested.

Alternative 4: 60 minutes interval. The numbers of patients in each block for surgery, medicine, general practice, medicine, and obstetric are 7, 7, 4, and 1 respectively. Priority, serving appointment patients firstly, is tested.

After running 30 replications for each alternative, the results are shown in table 4. Using 30-minute interval, average waiting time is about 54 minutes which is approximately 44% reduced from the base case (existing system). Using 60-minute interval, average waiting time is about 60 minutes which is approximately 37% reduced from the base case.

**Table 4.** Weighted average waiting time for each schedule.

Scenarios	WAWT (min.)	% of WAWT Reducing
Base	96.94	0
Alternative 1	54.05	44.25
Alternative 2	53.97	44.33
Alternative 3	60.45	37.64
Alternative 4	60.17	37.93

Examining in more detail, we found some different between appointment and non-appointment patients as shown in table 5. FIFO priority in alternatives 1 and 3 lead to the waiting time reduction of both appointment and non-appointment patients. While priority, serving appointment patients firstly, in alternatives 2 and 4 reduce waiting time for appointment patients more than non-appointment ones. Note that, in all four alternatives we tested, resources' utilization such as staffs, nurses and doctors are close to the existing system. As a result, resources in any appointment system are still effective.

**Table 5.** Waiting time and percent of reduction for each alternative.

Scenarios	AWTA(min.)	%AWTA Reduced	AWTNA(min.)	%AWTNA Reduced
Base	117.10	0	74.79	0
Alternative 1	51.77	55.79	56.41	24.58
Alternative 2	37.46	68.01	70.44	5.82
Alternative 3	59.46	49.22	61.50	17.77
Alternative 4	46.34	60.42	74.80	-0.02

#### 4. Conclusion

We study an outpatient department in a Thai hospital, which faces patients' waiting time problem. With the current single block system, an average waiting time of appointment patients are 40% longer than that of non-appointment patients. Consultation rooms and triages are the most congested areas. Our proposed appointment system can effectively manage patients matching with nurses and doctors' service. All multiple block, fixed interval appointment systems proposed in this paper outperform the current system. The results show that 30-minute appointment intervals reduce approximately 44% of average waiting time while 60-minute appointment intervals reduce approximately 37%. Priority, serving appointment patients firstly, focuses on reducing average waiting time for appointment patients comparing to FCFS priority where types of patients are not affected. Our final proposed schedules are shown in table 6 and 7. Note that since the 30-minute and 60-minute interval seems to show only slight different (approximately 10 minutes), we support the use of either appointment schedule.

**Table 6.** Appointment schedule for 30-minute interval.

Consultation's appointment time	Number of patients each clinic			
	Surgery	General Practice	Medicine	Obstetric
9:00 – 9:30	4 <sup>a</sup>	2 <sup>a</sup>	4 <sup>a</sup>	-
9:30 – 10:00	4	2 <sup>a</sup>	4 <sup>a</sup>	-
10:00 – 10:30	4	2	4	1 <sup>a</sup>
10:30 – 11:00	4	2	4	1
11:00 – 11:30	4	2	4	-

<sup>a</sup>Four patients with laboratory test.

**Table 7.** Appointment schedule for 60-minute interval.

Consultation's Appointment time	Number of patients each clinic			
	Surgery	General Practice	Medicine	Obstetric
9:00 – 10:00	7(4,3) <sup>a</sup>	4 <sup>b</sup>	7 <sup>b</sup>	-
10:00 – 11:00	7	4	7	1 <sup>b</sup>
11:00 – 12:00	7	4	7	1

<sup>a</sup> Four patients with laboratory test and three patients without laboratory test.

<sup>b</sup> Four patients have a laboratory test.

For implementation, there will be some adding steps to make appointment according to our proposed model(s). First, the few earliest slots are exclusive for appointed patients. Then, for priority (ordering patients' queue after triage), we support the FCFS (first come first serve) due to the fairness between appointed and non-appointed groups. However, we leave final decision on the hospital management team to take into account other consideration such as whether there should be preference for appointed patient. In any circumstances, there will be extra requirement to track each patient's arrival time to the department. Also, among appointment patients, ones who have a laboratory test should have first priority for doctor's consultation. Then, the patients who arrive on appointment time have second priority. Last priority will then go to unpunctual patients and non-appointment patients. Normal practice of requesting patient to arrive before appointed time is enforced (i.e., at least one hour for patient with laboratory test and half hour for non-laboratory one).

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