Service Management –
Managing Queues

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Thursdays, 8:00 – 10:00 a.m.
Room HS 024, B4 1
1. Introduction
2. Service Strategy
3. New Service Development (NSD)
4. Service Quality
5. Supporting Facility
6. Forecasting Demand for Services
7. Managing Demand
8. Managing Capacity
9. Managing Queues
10. Capacity Planning and Queuing Models
11. Services and Information Systems
12. ITIL Service Design
13. IT Service Infrastructures
14. Guest Lecture – Dr. Roehn, Deutsche Telekom
15. Summary and Outlook
• **Necessity for Managing Queues**
• **Different Views of Managing Queues**
• 1) Psychological View
  • Determinants of Dissatisfaction with Waiting Time
  • Tools for Managing Queues
• 2) Queuing Systems (Systematic View)
  • Formalization of Queuing Systems
    • Exponential Distribution
    • Poisson Distribution
  • Queue Configuration
• Example: Managing Queues at Disneyland
“It is a common experience that a two minute wait can feel like nothing at all, or can feel like 'forever'.” (Maister, 1985)

• E.g., waiting for the bus together with friends on a sunny day vs. waiting for the bus alone on a cold rainy day.

• 77% of customers overestimate the amount of waiting time, 84% of employees underestimate the same waiting time: Passive vs. active waiting time. (Feinberg et al., 1989)

• Queuing experience for a service can influence the perception of overall service quality.

• Therefore: Waiting time needs to be considered and analyzed:
  • Objective, measurable waiting time (actual waiting time)
  • Subjective waiting time (tolerable, expected and perceived waiting time)

• Tools are needed to influence especially the subjective waiting time.
(Maister, 1985)
Necessity for Managing Queues

- **Queue**: „(...) wait queues are a buffer between the rate at which customers seeking service arrive and the rate at which service can be delivered (...)“ (Hall 1991).

**Two Laws of Service:**

- **First Law**: Satisfaction with a service depends on expected and perceived service
  - Satisfaction with service = Perception of service – expectation of service
  - If customer expects certain level of service and perceived service is higher: Satisfied
  - If customer perceives the same level, but has higher expectations: Dissatisfied
  - Can be transferred to waiting times

- **Second Law**: First part of service encounter influences perception of following parts
  - Halo-effect: If first part of service is perceived positively, the rest will also be perceived positively.
  - If this part is improved to be perceived positively: Can influence perception of whole service
  - First part is often waiting for the service: Investments should be made there

Waiting times and queues of customers need to be analyzed.

(Maister, 1985)
Agenda Lecture 9

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Different Views of Managing Queues

1) Psychological View
   - Psychological influences of customers regarding queues

2) Queuing Systems (Systematic View)
   - Formal view
   - Calculation of waiting time

3) Economic View (Lecture 10)
   - Costs of waiting time
     - Costs of keeping a customer waiting (e.g., dissatisfaction, reduced sale)
     - Costs of keeping an employee waiting (e.g., decreased efficiency)
   - Better use of restricted capacity by managing queues
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1) Psychological View: Determinants of Dissatisfaction with Waiting Time

- **Actual Waiting Time**: Objective measured time customers have actually waited for a service provision.

- Customers are dissatisfied in case of differences between several subjective times:
  - Tolerable waiting time
  - Expected waiting time
  - Perceived waiting time

- **Tolerable Waiting Time** \((T_t)\): Maximum time of wait that a customer accepts. Criteria for segmenting customers (e.g., elderly people perceive waiting time often differently than business travellers).

Depends on several variables:
- **Value of the consumer's time** \((C_t)\): Elderly people versus business travellers
- **Value of the service** \((V_p)\): Waiting for a pop star before a concert versus waiting for the bus
- **Intensity of need** \((I_n)\): Waiting for the doctor in case of an emergency versus in case of a preventive check-up
- **Accessibility of a substitutional service** \((A_s)\): Waiting for a free table in a restaurant: Switch to another restaurant
- **Discomfort of wait** \((C_d)\): Waiting in the rain in winter
- **Pace of live** \((P_l)\): Slow versus fast way of living

\[
T_t = f(C_t, V_p, I_n, A_s, C_d, P_l)
\]

(Kostecki, 1996)
1) Psychological View: Determinants of Dissatisfaction with Waiting Time

- **Expected Waiting Time (Te):** Time of wait presumed by the customer when he decides if he wants to wait for the service or not.
  - Factors influencing decision, e.g., number of customers queuing, speed of moving line, experiences with queues.
  - Consumer will wait if: \( Te < Tt \)
  - Otherwise, customer will leave and might switch to another service provider.
  - Actual waiting time should be below expected waiting time: Customer satisfied.

- **Perceived Waiting Time (Tp):** Duration of wait from the customer’s subjective point of view
  - Varies among different customers.
  - Satisfaction with waiting time depends on perceived and expected waiting time
    \[ \text{Satisfaction with waiting time} = Te - Tp \]
  - Satisfaction with waiting time might influence satisfaction with whole service.

(Kostecki, 1996; Maister, 1985)
1) Psychological View: Tools for Managing Queues

Tools for reducing perceived waiting time:

- **Reduction of unoccupied time**: If customers are occupied during waiting time for service, waiting is perceived to be shorter (e.g., reading magazines at a doctor’s waiting room).

- **Reduction of perceived time until service starts**: Occupying customers with service-related activities (e.g., handing out menus to customers waiting for a table in a crowded restaurant): Signals, that service has already started. Waits before service is perceived as longer than waits within the service process.

- **Fear makes perceived waiting longer (often irrational)**: Communication is important
  - Fear of being “forgotten”: If waiter in a restaurant ignores customers for a long time.
  - Fear of having chosen the wrong line at the supermarket check: a line at the supermarket or airport, and stood there worrying that we had, indeed, chosen the wrong line?
  - Fear of missing the connecting flight at the airport

- **Announcement of approx. waiting time**: Uncertain waits are perceived longer than known waits (e.g., knowledge of 30 minutes waiting time at a dentist’s is more agreeable than just to know that you have to wait)

(Maister, 1985)
1) Psychological View: Tools for Managing Queues

- **Explain why customers need to wait:** Unexplained waits feel longer than explained waits (e.g., doctor's receptionist informs customers that they will have to wait some time due to an emergency: Waiting time is accepted by customers).

- **Make waiting perceived in a “fair” way by customers:** “Unfair” waiting is perceived longer than “fair” waiting. People prefer being served in the order of their arrival (customer who comes in first is served first). If customers take numbers, nobody can push to the front. Serving in order of importance (high priority customers) is perceived as being unfair (should be done out of sight of standard customers).

- **Increase the perceived value of the service:** Customers are willing to wait longer for a more valuable service (e.g., people are willing to wait longer for a freshly cooked meal in a good restaurant than for a fast-food meal: Customers should be told that meals are prepared with fresh ingredients).

- **Encourage waiting customers to talk to each other:** Waiting alone feels much longer than waiting in a group (e.g., customers need the possibility to talk to other people while waiting).

(Maister, 1985)
10 Minutes

- Imagine you are the manager of a Microsoft call center. Every phone call is answered after at least 30 seconds. In an empirical examination, you have discovered that customers are willing to wait for 40 seconds at the most. However, they expect the call to be answered after 25 seconds. The actual waiting time is perceived as 45 seconds.

- Please classify the different waiting times mentioned here.
- Which problem could occur?
- What could be done to reduce this problem?

- Please write your answers down (papers will be collected).
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• Example: Managing Queues at Disneyland
Features of Queuing Systems

- **Calling population**: Customers requiring a service come from this.
- **Arrival process**: When servers are available, customer is served. Otherwise he has to queue. Customer might leave immediately (balk).
- **Queue configuration**: Queues might have different structures. Customer might leave after joining the queue (renege).
- **Queue discipline**: Way of selecting a customer (e.g., first-come, first-served)
- **Service process**: Service is provided (one, several or no server needed)
- **Departure**: Customer leaves after provision of service. He may return (calling population) or leave forever (no future need for service).

(Fitzsimmons & Fitzsimmons, 2011)
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Arrival Process

Two methods for formalizing queuing systems:

- Exponential distribution
- Poisson distribution

**Poisson distribution** (number of patients arriving per hour)

- 1 arrival
- 2 arrivals
- 0 arrivals
- 1 arrival

**Exponential distribution** (time between 2 arrivals in minutes)

- 62 min.
- 40 min.
- 123 min.

(Fitzsimmons & Fitzsimmons, 2011)
Analysis of arrival times of customers:
Calculation of interarrival time (time between arrivals of two customers): **Exponential distribution**

- Distribution of interarrival times is exponential (due to empirical studies)
- Shape of curve of interarrival times: Exponential distribution (high frequency at the origin which decreases quickly)
- Variables:
  - $\lambda = $ Average arrival time within a certain interval of time (e.g., minutes, hours)
  - $t = $ Time between two arrivals
  - $e = $ Base of natural logarithms
  - $1/\lambda = $ mean
  - $1/\lambda^2 = $ variance
- Continuous probability density function of exponential distribution:
  \[ f(t) = \lambda e^{-\lambda t} \quad t \geq 0 \]
- Cumulative distribution function: Probability that time between two arrivals is $t$ or less
  \[ F(t) = 1 - e^{-\lambda t} \quad t \geq 0 \]

(Fitzsimmons & Fitzsimmons, 2011)
Example: At a doctor’s office, the mean time between the arrivals of two patients is 2,4 minutes. What are the probability density function and the cumulative distributive function? What is the probability of a patient arriving 5 minutes after another patient has arrived?

- \(1/\lambda = \text{mean (2,4)}\)  \(\lambda = 1/2,4 = 0,4167\) arrivals per minute
- Number of patients per hour: \(0,4167 \times 60\) minutes = 25 patients
- Probability density function:
  \[f(t) = 0,4167 \times e^{-0,4167t} \quad t \geq 0\]
- Cumulative distributive function
  \[F(t) = 1 - e^{-0,4167t} \quad t \geq 0\]

Use cumulative distributive function to calculate probability of a patient arriving after 5 minutes:

\[t = 5\]
\[F(5) = 1 - e^{-0.4167(5)} = 0.876\]

(Fitzsimmons & Fitzsimmons, 2011)
2) Queuing Systems: Formalization of Queuing Systems: Poisson Distribution

**Poisson distribution**: Discrete probability function
Calculates the probability of \( n \) arrivals during the time interval \( t \)

\[
f(n) = \frac{(\lambda t)^n e^{-\lambda t}}{n!} \quad n = 0, 1, 2 \ldots
\]

- **Variables**:
  - \( \lambda \) = Average arrival time within a certain interval of time (e.g., minutes, hours)
  - \( t \) = Number of time periods (usually \( t = 1 \))
  - \( n \) = Number of arrivals
  - \( e \) = Base of natural logarithms
  - \( \lambda t \) = mean
  - \( \lambda t \) = variance

(Fitzsimmons & Fitzsimmons, 2011)
Example: At a doctor’s office, 25 patients arrive per hour on average. What is the Poisson distribution function? What is the probability of 0 patients arriving within one hour?

- $\lambda = 25$
- $t = 1$
- $n = 0$

$$f(n) = \frac{(25 \times 1)^n}{n!} e^{-25 \times 1} \quad n = 0, 1, 2 \ldots$$

$$f(0) = \frac{(25 \times 1)^0}{0!} e^{-25 \times 1} = e^{-25} = 1.4 \times 10^{-11}$$

Comparison of Exponential and Poisson distribution

Two alternative distributions show the same process, but in different ways. Therefore:

- Exponential distribution with mean of interarrival times of 2.4 minutes is the same as Poisson distribution with mean of number of arrivals per hour of 25 (= 60 min./2.4).

(Fitzsimmons & Fitzsimmons, 2011)
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Several types of queuing systems possible:

- **Number of employees serving the customers**
  - One counter
  - Several counters

- **Queue arrangement**
  - Single queue
  - Multiple queues
  - Taking numbers

- **Single queue (with several counters):**
  - First person in queue goes to next available service counter.
  - First-come, first-served rule: All customers are served according to their arrival.
  - Fear of choosing the “wrong” queue is reduced, as people are served one after another.
  - Jumping the queue is hindered: Perceived fairness of service is increased.
  - Privacy of customers being served is increased: Nobody stands directly behind them.
  - Negative aspect: One long queue might be perceived as long waiting time: Customers leave
  - Used e.g., in banks and post offices

(Fitzsimmons & Fitzsimmons, 2011)
2) Queuing Systems: Queue Configuration

• **Multiple queues:**
  - Several queues, each served by one employee
  - Customer has to choose a queue
  - Customers can switch queue
  - Service can be differentiated: Special queues for first class customers or fast lane in supermarket for people with only a few items
  - Fewer people in one queue might reduce perceived waiting time
  - Negative aspect: “Fear” that other queues might move faster
  - Used e.g., in supermarkets

• **Taking numbers (with several counters):**
  - After arriving, customers are assigned a place in the line via taking a number on a slip of paper. Numbers are displayed on a monitor.
  - Customers do not need to stand in line, but can wander around
  - Customers often buy more products than they intended
  - Variation of single queue
  - “Fear” that place in line is taken by someone else is reduced
  - Negative aspect: Customers need to pay attention to the display of numbers.
  - Used e.g., in public agencies

(Fitzsimmons & Fitzsimmons, 2011)
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Example: Managing Queues at Disneyland

- **Disneyland**: Often long queues with long waiting times in at attractions
  - Demand for attractions fluctuates daily, weekly and seasonally.
  - Customers waiting a long time are dissatisfied

- **Traditional ways** of managing waiting lines:
  - Lines are split: Customers have to wait outside the building, inside the building and again right in front of the riding attraction (Queue Configuration)
  - Lines are “hidden”: Queues are looped around corners to avoid arriving customers seeing the whole queue (Queue Configuration)
  - Distraction from waiting: Displays showing films within the queuing area (Psychological tool)

- **Virtual queue**: "(...)
  - Computerizes queue management system: Returning later and therefore not having to wait (Queue Configuration)
  - Forecasting system for expected waiting times at certain attractions (Queue Configuration)

(Cope et al., 2008)
Example: Managing Queues at Disneyland

- Virtual queue: Fastpass:
  - Customers can get a Fastpass for certain attractions
  - Number of passes and stated time depend on time of day, number of people in park and popularity of attraction
  - Time window of 60 minutes for entry of the attraction at a later time of the day
  - Customers then just need to wait for a short time in a separate queue
  - Customers do not need to stand physically in line, but do other things

Restriction: Customers can only hold one Fastpass at the same time.

http://www.youtube.com/watch?v=lWIBr7DmXTk

(Cope et al., 2008)
Example: Managing Queues at Disneyland

• **Measure:** Customer can do other activities instead of standing in the line.

• **Main effects:**
  - Waiting time for later visit of attraction is not perceived as waiting.
  - Actual waiting time is reduced (also for people standing in the standard queue).
  - Demand for attraction is better allocated to less frequented times (e.g., lunch time).

• **Additional effects:**
  - Customers can visit more attractions at one day.
  - While not waiting in the queue, customers might purchase things in shops (additional revenue).

• **Final results:**
  - Higher customer satisfaction
  - Higher revenue per customer

“(…) every minute spent waiting in line is a minute that the customer is not generating revenue.” (Cope et al., 2008)

(Cope et al., 2008)
Example: Managing Queues at Disneyland

Disney’s apps: Customer’s possibilities for reduction of waiting times, e.g.,

- **Mouse Wait**: App for information on real time waiting times of different attractions
  - Tool for spontaneous decision of which attraction to choose
  - Can be used while being in the park

- **Walkee Disneyland iGuide**: App with information on attractions and waiting times
  - Tool for planning the trip in advance and during visit
  - Shows current waiting times of attractions
  - Can be used for making an itinerary of the visit

- **Disneyland California Mini Guide**: App with general information on attractions, shows and restaurants, for trip planning
  - Tool for planning the trip in advance
  - Shows location of attractions with average waiting times
  - Shows attractions where Fastpass is available
  - Shows nearby shops and restaurants of attractions

(http://ipod.about.com/od/bestiphoneapps/tp/top-disneyland-iphone-apps.htm)
Outlook

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Literature

Books:

Papers:

Others
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