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Optimization of a call centre's performance using queuing theory approach

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Summary

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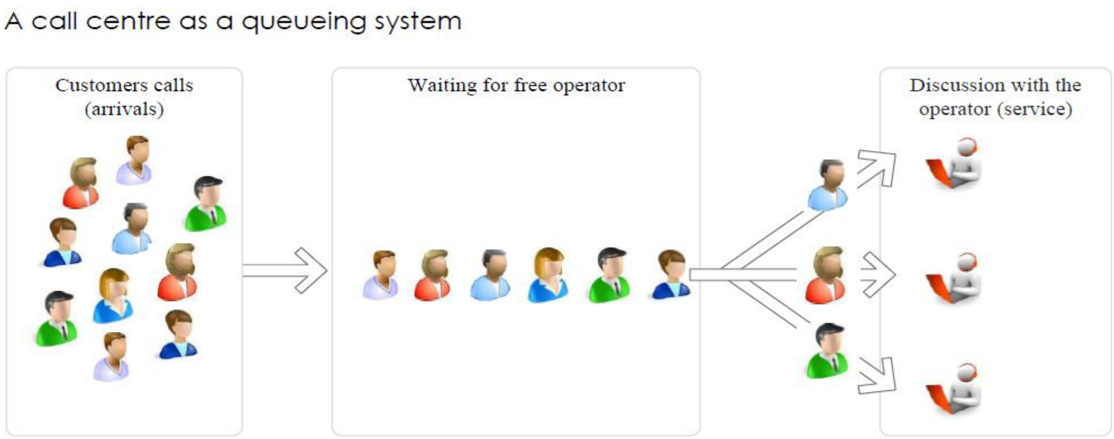
Introduction

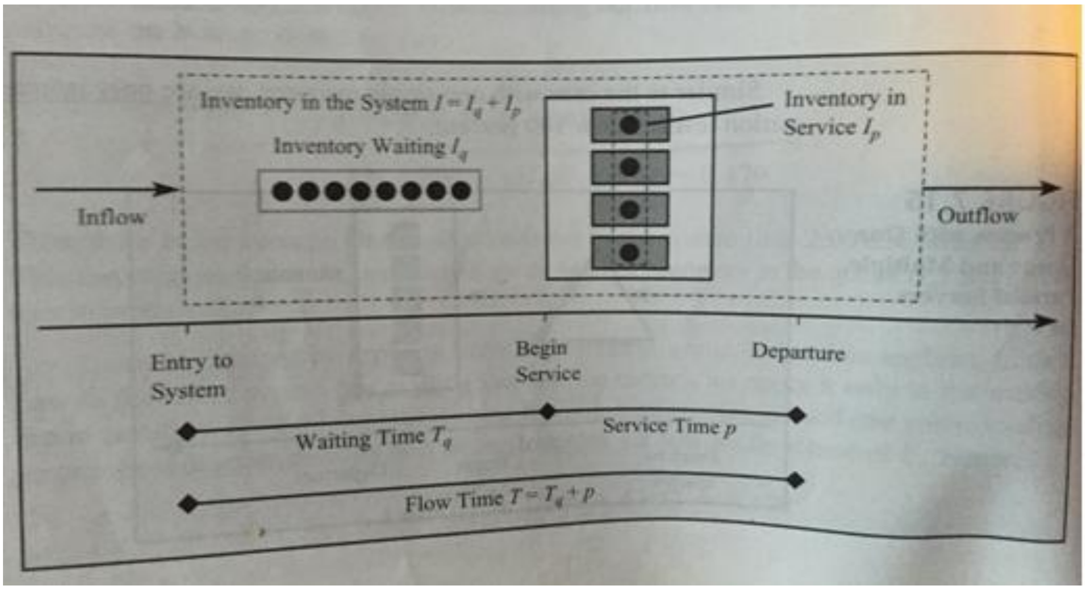
Problem statement

I wish to do my research on a Norwegian callcentre. A call center or a contact centre is a physical place where telephone calls from or to customers are handled by an organization (Stolletz, 2012). The operators, agents or customer service representatives working in a call center are the ones who answer enquiries from customers by telephone for a business. They can also make call to customers for telemarketing or market research. Depending on which direction the contact between the customer and the agent is initiated, we can differentiate between inbound and outbound call centers (Stolletz, 2012). My research will only focus on inbound call center service where operators receive incoming calls from customers, for example regarding product support or information enquiries from consumers. So therefore this form of call center is driven by random customer call arrivals (Stolletz, 2012). And because of this there will be (on average) both customers waiting for an agent and agents waiting for a customer (Stolletz, 2012).

I wish to study the call centre viewed as a queuing system. A call centre as a queuing system is illustrated in the figure below:



(source: Brezavscek and Baggia, 2014, page 11)



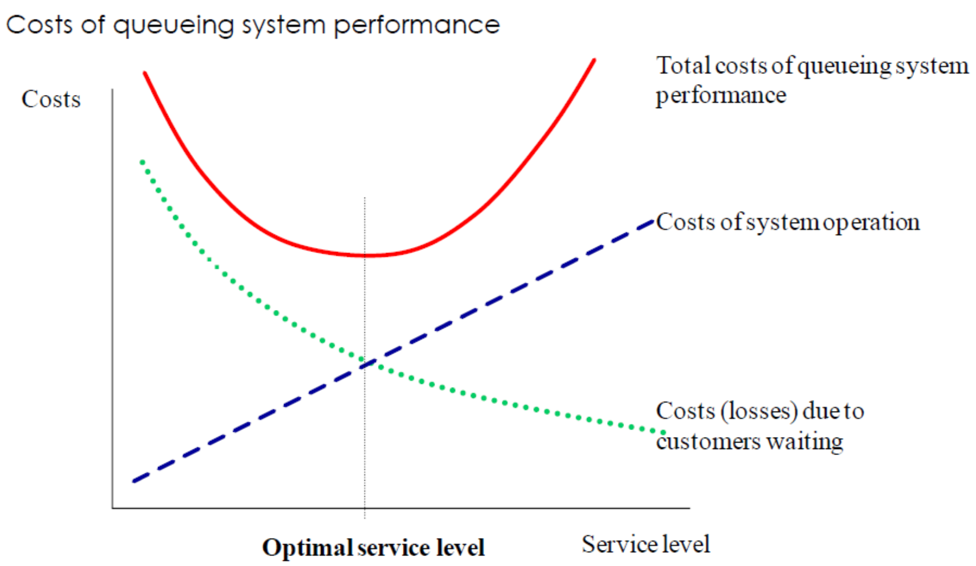
(source: Cachon and Terwiesch, 2009, page 142)

A queuing system in a call centre consists of one or more service units (i.e. servers which are operators ready to service customers), arrivals of customers demanding the service, and the service process. Whenever it is not possible to serve all customers at once, queues are formed. In this case the calling customer will be put in a waiting area or buffer (this is when you listen to music in a call centre) (Cachon and Terwiesch, 2009). Here customers can wait in a queue for an operator to become free regardless the number of customers in the queue (Brezavscek and Baggia, 2014). After waiting, they will be sent to a "service room" where a free operator will serve them.

To achieve customer satisfaction, short expected *waiting times* are important (Stolletz, 2012). Performance of the call center can be measured by looking at waiting times, availability of service or customer abandonment (Stolletz, 2012). Improvement of these technical performance measures are possible if the call center management hires more agents. However, in a call center the operating expenses are mainly driven by costs associated with these agents. Around 60-70% of the operating expenses consists of personnel-related costs (Stolletz, 2012).

When queues occur, this will lead to waiting costs (losses) for the call centre. For example costs related to customers who hang up while waiting for service because they are tired of waiting (Cachon and Terwiesch, 2009). This is lost throughput (abandoned calls). There will also be increased line charges because of the special phone number (800- numbers) that a lot of call centers use (Cachon and Terwiesch, 2009). Line charges are incurred for the actual talk time as well as for the time the customer is on hold. This is holding costs (line charges) for the call centre (Cachon and Terwiesch, 2009). Also there will be lost goodwill (Cachon and Terwiesch, 2009). These costs will increase with the number of customers in the queue.

So we have to balance these two costs: costs of system operation and waiting costs. As mentioned earlier, if we want to decrease waiting costs and increase service level ensuring better system performance (by improving certain performance measures), new investments must be made, but this will lead to higher costs of the queuing system operation. So we have to find the right balance between costs and service level. The figure below illustrates that it is possible to find the optimal service level which gives the minimum total costs of the queuing system performance by balancing both costs of system operation and costs due to customers waiting (Brezavscek and Baggia, 2014).



(source: Brezavscek and Baggia, 2014, page 8)

To determine the optimal service level various quantitative characteristics (performance measures) of the queuing system is used (Brezavscek and Baggia, 2014). These variables can be calculated using queuing models (queuing models= a mathematical representation of the characteristics and constraints of the queue (Koole and Mandelbaum, 2002)). These variables must be balanced in a certain way so that we achieve optimal service level where total costs of queuing system performance is lowest (Stolletz, 2012).

The imbalances of acceptable technical performance measures and the economic performance of the call center has to be adjusted by the call center management (Stolletz, 2012).

So in this thesis I would like to select one Norwegian call centre and focus on its inbound call centre services. I want to give "free consulting help" to the Norwegian call centre I select. I will view their inbound call centre service as a queuing system and conduct a performance analysis on it. I want to analyze the performance of the call centre using a suitable queuing model (mathematical model, Erlang-C?), and the values of the performance measures of the queuing system will be calculated using the selected queuing model. Based on the performance analysis, I want to give suggestions for optimization of the queuing system, where optimal service level is achieved which is also the point where total costs of the queuing system performance are minimal.

So this leads to the research question:
How can the queuing system performance of a Norwegian inbound call centre service be optimized by analyzing its performance measures using queuing theory approach? What changes can be done to the performance measures (calculated using a suitable queuing model)in order to achieve optimal service level where at the same time total costs of the queuing system performance are minimal?

On December 15th I had a meeting with chief operating officer Rune Lonkemoen from Proffcom regarding my research question. Proffcom is a call centre company that provides consultancy services for call centres. Other companies that want to outsource their customer service part (which is non-core part) of business, can do it to Proffcom. Lonkemoen gave me valuable insight into what is the relationship between waiting time and customer satisfaction. He told me that, whether waiting time affects customer satisfaction depends on what the customer is waiting for. It depends on the customer's perception of the queuing experience. He adviced me to target call center companies like Peppes Pizza, Canal digital and ice,net. In these companies, waiting for too long in queue can lead to customer dissatisfaction and the customer might go for a competitor instead. This results in loss of sales. Lonkemoen also mentioned that it is a good idea to set a 80/20 service level (80% of customers must be answered within 20 seconds) constraint when planning staffing, because he mentioned that this 80/20 service level is national standard for these type of companies. The research question will be updated and changed when established contact with a company.

Relevant literature and theory

There exists plenty of research papers on how my research question can be answered. The goal of this thesis is to make a performance analysis of the chosen call centre's current call centre performance and make changes to performance measures to optimize performance and come up with a optimized model. And suggest them this optimized model where optimal service level is achieved and costs are optimal. I want to improve an existing model. Results of previous research on call centre optimization shows that it can be done using the queuing theory approach (Brezavscek and Baggia, 2014). Queuing theory can be used to balance the cost of increased capacity against the increased productivity and service (Osahenvemwen and Odiase, 2016).

First I will give a thorough definition of queuing theory, and how it is applied to call centers. After that present research articles that discuss the application of queuing theory in real world cases, which represents work that has previously been done in my area of study. Then draw conclusions to why they are relevant to my thesis. Queuing theory is a branch within the field of operations research. Operations Research is an approach used to improve service delivery (Shanmugasundaram and Umarani, 2015). The results of operations research are used for making decisions about the resources needed to provide service (Shanmugasundaram and Umarani, 2015). This field is relevant for my research question, so main focus will be on reviewing literatures within the field of operations research.

According to professor Leonard Kleinrock (1975) who is a computer scientist that developed queuing theory in the 1960's, he explains that queuing theory is a mathematical discipline that studies the phenomena of standing, waiting and serving.

Any system in which an arriving flow of customers or units requesting service, and servers waiting to provide service to them, where arrivals place demands upon a finite-capacity resource may be termed a queuing system (Kleinrock, 1975). In particular, if the arrival times of these demands are unpredictable, or if the size of these demands is unpredictable, then conflicts for the use of the resource will arise and queues of waiting customers or units will form (Kleinrock, 1975). In this way it is called a queuing system. Any system where a queue is made and served can be modeled and studied by the use of queuing theory (Kleinrock, 1975). Queuing theory make use of mathematical models and performance measures to assess the flow of customers through a queuing system and hopefully improves it. Though queues are often made up of physical lines of people or things, it is also possible for the queues to be invisible as with telephone calls waiting on hold in a call centre (Green, 2011). In my call center case customers wait in a virtual queue.

Queuing theory has a variety of applications and has been used largely by the service industries (Nosek and Wilson, 2001). Queuing theory has in the past been used to assess such things as staff schedules, working environment, productivity, customer waiting time, and customer waiting environment (Nosek and Wilson, 2001). So this theory will in my case be used to assess staff scheduling and customer waiting environment in the call centre.

There are basically three things that queuing theory is based on - a queuing model which is a mathematical representation of the characteristics and constraints of the queue, a real world system such as a telephone network or a call center that you wish to model, and a mapping between the two (Koole and Mandelbaum, 2002). This is exactly what I want to do in this thesis with my call centre case, I want to present it in a mathematical model so that I can analyze its queuing system performance. There exists a great number of contributions in the literature that proves that queuing models are a useful and applicable tool that can be used to analyze call centre efficiency (Brown, Gans, Mandelbaum, Sakov, Shen, Zeltyn and Zhao 2005; Dombacher 2010 and Koole and Mandelbaum 2002). Relevance and usefulness of the results that are obtained through such an analysis depends on proper selection of a mathematical model, which is based on three elements of the queuing system: the arrival process, the service times and the queuing discipline (Brezavscek and Baggia, 2014). Parameters such as the arrival process, service times and the number of agents, is what queuing models are built from. To apply a queuing, the call center must first estimate these parameters based on historical data (Koole and Mandelbaum, 2002). In specifying a queuing model, assumptions about the probabilistic nature of the arrival and service processes must be made (Green, 2011). Appropriate selection of a mathematical model, is based on knowledge of the probability density functions of inter-arrival times (which is times between two successive incoming calls) and service times (call length), that are both random variables (Brezavscek and Baggia, 2014). Cachon and Terwiesch 2009 explains how and why an arrival process is analyzed.

A big risk related to any mathematical model is that these tools always provide us with a number (or a set of numbers), independent of the accuracy with which the inputs we enter into

the equation reflect the real world (Cachon and Terwiesch, 2009). There are two questions that are important to answer before selecting queuing model and starting to calculate performance measures, answering these questions will improve the predictions of the model substantially (Cachon and Terwiesch, 2009). The selected model will give us more accurate predictions. The questions are:
- Is the arrival process stationary; that is, is the expected number of customers arriving in a certain time interval constant over the period we are interested in (Cachon and Terwiesch, 2009)?

- Are the inter-arrival times exponentially distributed, and therefore form a so-called Poisson arrival process (Cachon and Terwiesch, 2009)?

And also whether the service times are exponentially distributed influence the choice of queuing model.

Collecting historical data about the arrival process and service process and determining its probabilistic nature is important because the mapping between the mathematical model and real world system will be more precise. The mathematical model's predictions about the performance measures will be more accurate and realistic.

Measure of variability, coefficient of variation CV

Waiting time in inbound call centers occur because of variability. Random customer call arrivals is what drives an inbound call centre. Because of this, on average we have both customers waiting for an agent and agents waiting for a customer (Stolletz, 2011). The service process I am analyzing is assumed to exhibit random variability in demand. Queue arise when the demand for service exceeds the capacity, which are often caused by random variation in service times and the times between customer arrivals (Osahenvemwen and Odiase, 2016).

It is possible to measure variability. Variability is measured as the coefficient of variation (CV) of a random variable as:

Coefficient of variation = CV= Standard deviation / Mean. (Cachon and Terwiesch, 2009)

As discussed, there exists variability in both the time between arrivals and the duration of

each call. So the variability of an arrival (demand) process can be measured like this:
CVa = Standard deviation of interarrival time/Average interrarival time. Variability in service time or activity time can be measured as: CVp =Standard deviation of activity time / Average activity time.

If an arrival process has exponentially distributed interarrival times or not, affects the choice of queuing model. It is the same case for the service process. Whether the service process has exponentially distributed service times or not also affects choice of queuing model. If interarrival times are exponential, then the mean is equal to the standard deviation and this would give a CVa =1. The same would happen to service times if they were exponentially distributed, it would have a CVp=1. If the interarrival times and service times were not exponentially distributed, then their CV's would have to be calculated using the CV formulas given above.

Queuing models

Sanjay Bose (2002) explains in his book "Introduction to Queuing Systems" that queuing models can be represented using Kendall's notation which comprise of three factors, A/B/C. This is a queuing model's notation and details of its notation is:
A: Interarrival time distribution
B: The service time distribution
C or s: Number of servers or service channels. In my call centre case this is the number of agents.

Typical notations for A and B:
These notations are used for describing the probability density function of inter-arrivals and service times.
M - Poisson process. Exponential distribution. (M stands for memoryless).
Ek - Erlang distribution with k phases.
D - Deterministic times.
G - General distribution, service time can have an arbitrary distribution (Bhat, 2015).

This is important to know because most of the existing literature on Queuing theory use these notations to describe the characteristics of a queuing system.

The M/M/s model or Erlang C model is the most commonly used queuing model (Green, 2011). The assumptions for this model is that there is a single queue with unlimited waiting room that are going to be serviced by s identical servers (Green, 2011). Customers arrive according to a Poisson process with a constant rate, and the service times has an exponential distribution (Green, 2011). The arrivals are serviced on a FCFS (First-come-first-served) basis (Tiwari, Gupta, Joshi, 2016). For this queuing model there are a set of formulas available that enables the calculation of various performance measures of the queuing system. These formulas calculate performance measures such as: The average number of customers in the system, that is, the number in line plus the number being served (Chowdhury, Rahman, Kabir, 2013). The average time a customer spends in the system, that is, the time spent in line plus the time spent being served (Chowdhury, Rahman, Kabir, 2013). The average number of customers in the queue alone (Chowdhury, Rahman, Kabir, 2013). Probability that wait time is greater than t time.

The advantages of this model is that it requires only 3 parameters, so it can be used to obtain performance estimates with very little data (Green, 2011). There are disadvantages as well with this model. According to Koole and Mandelbaum (2002) M/M/s could turn out highly inaccurate because reality often go against its underlying assumptions. In the M/M/s, the coefficient of variations for interarrival times and service are both equal to 1. If we have non-exponential service times, then the M/G/s model would be more suitable to model the queuing system (Koole and Mandelbaum, 2002). Here one must resort to approximations, out of which it turns out that service time affects performance (efficiency of queuing system, meaning expected waiting time) through its variability, coefficient of variation (Koole and Mandelbaum, 2002). If the CV of service times is substantially different than one, the use of the M/M/s model may significantly underestimate or overestimate actual waiting time (Green, 2011). This is why it is better to use the M/G/s model, its more accurate, it takes into account variability in service times. When using the M/G/s model, the performance weakens when stochastic variability in service times increases (Koole and Mandelbaum, 2002). And improves when variability decreases. The M/G/s 's formula for calculating expected waiting time shows the impact of variability on waiting time (Green, 2011). The G/G/s model takes into account nonexponential interarrival times as well, and here CVa is different from 1. Variability in interarrival times have the same effect on expected waiting time as variability in service times does (Green, 2011).

These are possible queuing models I can use for performance analysis of my call centre case with Peppes Pizza, ice.net or Canal digital. Initially these are the basis's I set when going forward to start my analysis on the performance of the call centre I select. The right selected queuing model makes it possible for me to calculate the values of the performance measures more accurately. The formulas available for each model, enables the calculation of various performance measures which can be used to help design a new service system or improve an existing one (Green, 2011).

Various models and their characteristics will be discussed further on in the literature part of the master thesis using relevant literature from Raik Stolletz (2012), and a suitable model to my particular problem will be finalized. More complex models that take into account features like for example the number of customer classes, the number of differently trained agent groups, the limitation of the waiting room, or the customer's impatience will be looked into. All according to what fits best with my call centre case. How these features affect call centre performance are explained in the book "Performance Analysis and Optimization of Inbound Call Centers" by Raik Stolletz (2012), and I will be using this literature extensively. A simpel model I select initially, will later be extended by more realistic assumptions.

Key performance measures that I am considering when aiming to achieve call centre performance optimization are:
- The expected waiting time (for customers waiting in line to be serviced).
- The expected number of waiting customers.
- The probability that the calling customer will have to wait.
- The call centre service level (defined as the percentage of calls whose waiting time in the queue is not larger than a given threshold, an acceptable waiting time, typically 20 to 30 seconds (L'Ecuyer, 2006)). After talking with Rune Lonkemoen from Proffcom I was told that the national standard for call centres is the 80/20 service level. Which means that 80 percent of the customers wait no more than 20 seconds.

The quality of call centre service is related to customer satisfaction with the service, and this is often dependent on how long calling customers have to wait before their calls are answered (Brezavscek and Baggia, 2014).

So that's why I have decided to focus on these performance measures, because they depend on customer's waiting before their calls are answered (Brezavscek and Baggia, 2014). Because these measure customer satisfaction and this says something about the quality of the call centre's service. Short expected waiting times are important to achieve customer satisfaction (Raik Stolletz, 2012). So that's why I am initially focusing on these performance measures, to achieve optimal quality of service. The goal of this thesis is that the optimal service quality must be provided at optimal cost.

As in my call centre case with Peppes Pizza, Canal Digital or Ice.net, waiting time will affect customer satisfaction. Like for example ice.net's call centre, has received many complaints from their customers about long waiting times in queue and that they are understaffed. I can refer this to an article written in Dagbladet on 7. July. Dissatisfied customers may cancel their subscription with ice.net and be tempted to go for their competitors instead. This is a loss for ice.net. A highly satisfied customer is more likely to spread the positive experience by word of mouth advertising (Nosek and Wilson, 2001). A dissatisfied costumer will most likely be more than willing to share his or her bad experience with whoever will listen, and this will have an obvious negative impact on revenues (Nosek and Wilson, 2001). People who call to order pizza might get annoyed by the long waiting time and then might turn to a competitor instead.

The article "Optimization of a Call Centre Performance Using the Stochastic Queueing Models" (2014) by Brezavscek and Baggia discusses the application of queuing models aimed at optimizing a Slovenian telecommunication provider's call centre. According to this article, an important factor of call centre optimization is the determination of the proper number of operators considering the selected performance measures. It is shown here how to determine the right balance between various performance measures to achieve call centre performance optimization where service level and cost are optimal. This literature is quite relevant for my research question.

Optimize costs

Raik Stolletz (2012) explains that costs in an inbound call centre can consist of different components. These are: Salaries 63%, hiring and training costs 6%, costs for office space 5%, trunk costs 5%, IT and telecommunication equipment 10%. This is a typical cost structure in a call centre. The hourly wages of an agent is the main component. Cost functions are shown and here they consider homogenous agents and homogenous customers, and for simplicity this is what I am considering in my call centre case. Stolletz (2012) talks about that different objective function can be used to make operational decisions regarding the number of agents to put to work in an inbound call centre. He describes two approaches: the minimization of a cost function and a profit-based approach. An optimal staffing level can be decided by minimizing an objective function that consists of different cost components (Stolletz, 2012). He explains that an optimization problem can be solved by minimizing cost functions subject to constraints set on technical performance measures. Certain constraints on the service level, expected waiting time and the probability of receiving service have to be satisfied. This is called the minimization of a cost function approach. This approach would result in an optimum of 0 agents if there were no constraints on technical performance measures (Stolletz, 2012). Based on call forecasts, a weekly or monthly agent schedule, must be built according to a particular objective function and certain constraints (Stolletz, 2012). To derive the objective value for a given staffing level, the performance of the queuing system has to be evaluated (Stolletz, 2012). So therefore, the performance analysis for different staffing levels is an important part of the planning of agent schedules (Stolletz, 2012).

This literature from Raik Stolletz (2012) is highly relevant for my research, because I have to maintain certain performance measures (constraints) to provide satisfying service quality to customers in my call centre case. And this must be done at minimum costs. Relevant costs like labour costs, line charges will be put into the objective function and optimized. Proffcom can possibly provide me with software tools to do the linear programming. This literature will be studied more extensively in the coming weeks. Which decision variables I need will be looked into in the coming weeks.

Simulation vs. queuing theory

It is discussed in the literature that simulation methodologies is, in addition to analytical models, also an viable option to use for performance modeling and subsequent decision support (Brezavscek and Baggia, 2014). The analytical approach is not accurate enough, is what some authors are arguing, like Akhtar and Latif (2010), because it does not mimic randomness.

Analytical models (queuing theory) is a more fitting choice when there is little information available and it is required to make assumptions (Mathew and Nambiar, årstall). According to Green (2011) queuing models needs very little data, compared to what simulation models need. So what this means is that they are cheaper to develop and use.

The book "Matching Supply with Demand, An Introduction to Operations Management" (2009) by Gerard Cachon and Christian Terwiesch is very useful literature for my thesis because it explains what data to collect and how to analyze the data. What data are required to do the performance analysis of call centre is thoroughly explained. Formulas on how to calculate various performance measures capturing the service quality provided to customers, is presented here. The book gives suggestions on ways to reduce waiting time in a queuing system by choosing appropriate capacity levels and redesigning the service system.

Importance/relevance of my topic - WHY:

Inbound call centers make up a large and growing part of the global economy (Aksin, Armony and Mehrotra, 2007). Call centers are frequently used by organizations for technical support for end users (Brezavscek and Baggia, 2014). They are a preferred and prevalent way for many companies to communicate with their customers (Koole and Mandelbaum, 2002). A call centre usually represents the first contact of a customer with a given company. Call centers serve as the "public face" for many firms (Kim and Park, 2007). Therefore, the quality of the call center's service is of high importance (Brezavscek and Baggia, 2014). So giving a good first impression to customers is important. In general, the quality of call centre service is related to customer satisfaction with the service (Brezavscek and Baggia, 2014). In my thesis I restrict myself to customer satisfaction. Providing poor service quality to customers might tarnish the reputation of the company. The image customers have of the company will be bad. That's why it is important for call centres to make sure they provide high quality of service.

Inbound call centers are typically very labor-intensive operations and cost of workforces comprise a large portion of the total costs in the call centre (Kim and Park, 2007). Almost 60-70 percent of the total costs for operating a call center involve wage and benefit expenses for personnel (Kim and Park, 2007). Since it make up such a big part of the total costs, it is crucial to determine the optimal number of call centre operators. This is what makes my topic so interesting, finding the right balance between cost and customer satisfaction/service quality is important. Maximize efficiency, minimize costs and provide high quality of service, all at the same time is a challenging task for call center managers (Aksin, Armony and Mehrotra, 2007) and it is this challenge that made me want to select my thesis topic.

Companies that focus on customer loyalty are increasingly using their centers to differentiate their product or service offering and drive customer satisfaction (Miciak and Desmarais, 2001) . They use it to differentiate them from competition. Gain competitive advantage. Cutting cost and enhancing effectiveness of call centre are directly connected with strengthening the competitiveness of the companies (Kim and Park, 2007). This shows that my research topic call centre performance optimization is important because it affects a company's competitiveness. A call centre that is running optimally might give a competitive advantage. That's why I think it is interesting to do research on my particular topic.

Queuing models can be used to do a mathematical analysis of the call centre performance. Data required for the mathematical analysis are usually easy to get, since modern technology enables automatic logging of all the events in the call centre. However, lack of expert knowledge in practice prevents the call centre from efficient usage of the data (Brezavscek and Baggia, 2014). Here is where my research will contribute. I will use theories from operations research to make good use of these data. I will use knowledge of queuing theory to utilize call centre data to come up with a optimized model (most efficient way of running, optimal service at minimum cost) for running the Norwegian call centre I select. The overall objective from a practical matter is to analyze the current call centre data and based on that suggest the Norwegian call centre with an optimized model (where service level is optimal at optimal cost, with appropriate number of call centre operators/agents) as an alternative to the not optimized operations model they are currently using. So in this way I show how to use call centre data in a efficient way, by suggesting a model that will optimize the Norwegian call center's performance. My research aims to provide the Norwegian call centre with a framework, when they want to run their call centre operations in the most efficient way. This is an approach for decision making in the call centre, and im making them known to this approach. An approach like this can be used in other call centers as well, the ones who want to run their call centre operations in the most efficient way.

I think my research is important because I'm finding a way for a Norwegian call centre business to run their operations in the most efficient way. Both parties, customer and call centre will be satisfied, considering customer satisfaction and cost. Service quality is important in call centre business as I mentioned in the beginning of this section. But must be provided in a cost efficient way (at an optimal cost level for the call center). This is why I think my topic is of great importance.

Research methodology:

Research strategy:

In this thesis I would like to describe the current situation/status of the queuing system of the inbound call center service in a Norwegian call centre. Various quantitative characteristics (performance measures) that describes the performance of the queuing system must be measured. Numerical data must be collected to calculate these performance measures (details about what these performance measures are and which queuing model is the most suitable for my Norwegian call centre case will be thoroughly discussed in the literature/theory part). To do the performance analysis I need numerical data.

The purpose of this thesis is to optimize the service level at minimum total costs in a inbound call centre service by changing variables that affect queuing system performance. Research in this field has been done many times before and there exists vast amount of literature/theory that describes how it can be a achieved. Results of previous research show that this can be done using queuing theory approach. The selected queuing model that is most suitable to my queuing case decides what data is to be collected. Therefore it is safe to say that my research will be of a deductive approach.

My research will be mostly quantitative,
since a queuing model which I will be using in my research is a mathematical representation of the queuing system. The queuing model requires numerical data in order to calculate the values of the performance measures which I want to balance to find the optimal service level. Therefore it is safe to say that this is a quantitative research.

- The current queuing system will be studied using queuing theory.
- This will be done using numerical data.

Research design:

The Research design of this research will be a case study where I will base my study on how the inbound call centre service of one selected Norwegian call centre can achieve optimal service level through performance analysis. I am only going to study the performance of the *inbound call centre service* of a call centre. I will be applying queuing theory in a real world case, for a Norwegian call centre, for optimization of its inbound call centre service's queuing system performance. By finding the right variation of the different variables that affect performance, I will improve an existing service system, to give optimal service and cost. So therefore I think a case study will be most appropriate because I am going to look at a single organization and in a specific case.

Data collection:

Secondary data:

I will collect data for the most part through secondary information about the inbound call centre service's operation. Obtaining the secondary data I need for my analysis is assumed to be uncomplicated since contemporary technology allows automatic logging of all the events in the call centre. So I am expecting that data needed for my analysis will be provided by the Norwegian call centre I am writing my thesis for.

Data I need, to calculate the performance measures will be collected through secondary information. One of the advantages of secondary data is that it is less time consuming and less costly to obtain.

When dealing with variability problems, it is important to have an accurate representation of the demand, which in my inbound call centre case shows the timing of customer call arrivals. So I am going to collect data about the call arrival (demand) process. I could possibly go to the Norwegian call centre I am writing my thesis for and take detailed notes of the time at which the call centre receives each call. If I continue my data collection for some period of time, I accumulate a fair quantity of arrival times. The table below is a depiction of how I want the collected data to look like.

TABLE 7.1 Call Arrivals at An-ser on April 2, 2002, from 6:00 a.m. to 10:00 a.m.

6:00:29	6:52:39	7:17:57	7:33:51	7:56:16	8:17:33	8:28:11	8:39:25	8:55:56	9:21:58
6:00:52	6:53:06	7:18:10	7:34:05	7:56:24	8:17:42	8:28:12	8:39:47	8:56:17	9:22:02
6:02:16	6:53:07	7:18:17	7:34:19	7:56:24	8:17:50	8:28:13	8:39:51	8:57:42	9:22:02
6:02:50	6:53:24	7:18:38	7:34:51	7:57:39	8:17:52	8:28:17	8:40:02	8:58:45	9:22:30
6:05:14	6:53:25	7:18:54	7:35:10	7:57:51	8:17:54	8:28:43	8:40:09	8:58:49	9:23:13
6:05:50	6:54:18	7:19:04	7:35:13	7:57:55	8:18:03	8:28:59	8:40:23	8:58:49	9:23:29
6:06:28	6:54:24	7:19:40	7:35:21	7:58:26	8:18:12	8:29:06	8:40:34	8:59:32	9:23:45
6:07:37	6:54:36	7:19:41	7:35:44	7:58:41	8:18:21	8:29:34	8:40:35	8:59:38	9:24:10
6:08:05	6:55:06	7:20:10	7:35:59	7:59:12	8:18:23	8:29:38	8:40:46	8:59:45	9:24:30
6:10:16	6:55:19	7:20:11	7:36:37	7:59:20	8:18:34	8:29:40	8:40:51	9:00:14	9:24:42
6:12:13	6:55:31	7:20:26	7:36:45	7:59:22	8:18:46	8:29:45	8:40:58	9:00:52	9:25:07
6:12:48	6:57:25	7:20:27	7:37:07	7:59:22	8:18:53	8:29:46	8:41:12	9:00:53	9:25:15
6:14:04	6:57:38	7:20:38	7:37:14	7:59:36	8:18:54	8:29:47	8:41:26	9:01:09	9:26:03
6:14:16	6:57:44	7:20:52	7:38:01	7:59:50	8:18:58	8:29:47	8:41:32	9:01:31	9:26:04
6:14:28	6:58:16	7:20:59	7:38:03	7:59:54	8:19:20	8:29:54	8:41:49	9:01:55	9:26:23
6:17:51	6:58:34	7:21:11	7:38:05	8:01:22	8:19:25	8:30:00	8:42:23	9:02:25	9:26:34
6:18:19	6:59:41	7:21:14	7:38:18	8:01:42	8:19:28	8:30:01	8:42:51	9:02:30	9:27:02
6:19:11	7:00:50	7:21:46	7:39:00	8:01:56	8:20:09	8:30:08	8:42:53	9:02:38	9:27:04
6:20:48	7:00:54	7:21:56	7:39:17	8:02:08	8:20:23	8:30:23	8:43:24	9:02:51	9:27:27
6:23:33	7:01:08	7:21:58	7:39:35	8:02:26	8:20:27	8:30:23	8:43:28	9:03:29	9:28:25
6:24:25	7:01:31	7:23:03	7:40:06	8:02:29	8:20:44	8:30:31	8:43:47	9:03:33	9:28:37
6:25:08	7:01:39	7:23:16	7:40:23	8:02:39	8:20:54	8:31:02	8:44:23	9:03:38	9:29:09
6:25:19	7:01:56	7:23:19	7:41:34	8:02:47	8:21:12	8:31:11	8:44:49	9:03:51	9:29:15
6:25:27	7:04:52	7:23:48	7:42:20	8:02:52	8:21:12	8:31:19	8:45:05	9:04:11	9:29:52
6:25:38	7:04:54	7:24:01	7:42:33	8:03:06	8:21:25	8:31:20	8:45:10	9:04:33	9:30:47
6:25:48	7:05:37	7:24:09	7:42:51	8:03:58	8:21:28	8:31:22	8:45:28	9:04:42	9:30:58
6:26:05	7:05:39	7:24:45	7:42:57	8:04:07	8:21:43	8:31:23	8:45:31	9:04:44	9:30:59
6:26:59	7:05:42	7:24:56	7:43:23	8:04:27	8:21:44	8:31:27	8:45:32	9:04:44	9:31:03
6:27:37	7:06:37	7:25:01	7:43:34	8:05:53	8:21:53	8:31:45	8:45:39	9:05:22	9:31:55
6:27:46	7:06:46	7:25:03	7:43:43	8:05:54	8:22:19	8:32:05	8:46:24	9:06:01	9:33:08
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6:30:41	7:09:34	7:25:48	7:45:32	8:08:28	8:23:30	8:33:27	8:47:04	9:06:48	9:36:17
6:30:53	7:09:38	7:26:30	7:46:22	8:08:31	8:24:04	8:33:30	8:47:06	9:06:55	9:36:37
6:30:56	7:09:53	7:26:38	7:46:38	8:09:05	8:24:17	8:33:40	8:47:15	9:06:59	9:37:23
6:31:04	7:09:59	7:26:49	7:46:48	8:09:15	8:24:19	8:33:47	8:47:27	9:08:03	9:37:37
6:31:45	7:10:29	7:27:30	7:47:00	8:09:48	8:24:26	8:34:19	8:47:40	9:08:33	9:37:38
6:33:49	7:10:37	7:27:36	7:47:15	8:09:57	8:24:39	8:34:20	8:47:46	9:09:32	9:37:42
6:34:03	7:10:54	7:27:50	7:47:53	8:10:39	8:24:48	8:35:01	8:47:53	9:10:32	9:39:03
6:34:15	7:11:07	7:27:50	7:48:01	8:11:16	8:25:03	8:35:07	8:48:27	9:10:46	9:39:10
6:36:07	7:11:30	7:27:56	7:48:14	8:11:30	8:25:04	8:35:25	8:48:48	9:10:53	9:41:37
6:36:12	7:12:02	7:28:01	7:48:14	8:11:38	8:25:07	8:35:29	8:49:14	9:11:32	9:42:58
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6:38:20	7:12:26	7:28:47	7:49:48	8:12:17	8:25:32	8:36:23	8:50:19	9:13:19	9:44:21
6:40:06	7:13:16	7:28:54	7:49:50	8:12:40	8:25:32	8:36:29	8:50:38	9:14:00	9:44:32
6:40:11	7:13:21	7:29:09	7:49:59	8:12:41	8:25:45	8:36:35	8:52:11	9:14:04	9:44:37
6:40:59	7:13:22	7:29:27	7:50:13	8:12:42	8:25:48	8:36:37	8:52:29	9:14:07	9:44:44
6:42:17	7:14:04	7:30:02	7:50:27	8:12:47	8:25:49	8:37:05	8:52:40	9:15:15	9:45:10
6:43:01	7:14:07	7:30:07	7:51:07	8:13:40	8:26:01	8:37:11	8:52:41	9:15:26	9:46:15
6:43:05	7:14:49	7:30:13	7:51:31	8:13:41	8:26:04	8:37:12	8:52:43	9:15:27	9:46:44
6:43:57	7:15:19	7:30:50	7:51:40	8:13:52	8:26:11	8:37:35	8:53:03	9:15:36	9:49:48
6:44:02	7:15:38	7:30:55	7:52:05	8:14:04	8:26:15	8:37:44	8:53:08	9:15:40	9:50:19
6:45:04	7:15:41	7:31:24	7:52:25	8:14:41	8:26:28	8:38:01	8:53:19	9:15:40	9:52:53
6:46:13	7:15:57	7:31:35	7:52:32	8:15:15	8:26:28	8:38:02	8:53:30	9:15:40	9:53:13
6:47:01	7:16:28	7:31:41	7:53:10	8:15:25	8:26:37	8:38:10	8:53:32	9:15:41	9:53:15
6:47:10	7:16:36	7:31:45	7:53:18	8:15:39	8:26:58	8:38:15	8:53:44	9:15:46	9:53:50
6:47:35	7:16:40	7:31:46	7:53:19	8:15:48	8:27:07	8:38:39	8:54:25	9:16:12	9:54:24
6:49:23	7:16:45	7:32:13	7:53:51	8:16:09	8:27:09	8:38:40	8:54:28	9:16:34	9:54:48
6:50:54	7:16:50	7:32:16	7:53:52	8:16:10	8:27:17	8:38:44	8:54:49	9:18:02	9:54:51
6:51:04	7:17:08	7:32:16	7:54:04	8:16:18	8:27:26	8:38:49	8:55:05	9:18:06	9:56:40
6:51:17	7:17:09	7:32:34	7:54:16	8:16:26	8:27:29	8:38:57	8:55:05	9:20:19	9:58:25
6:51:48	7:17:09	7:32:34	7:54:26	8:16:39	8:27:35	8:39:07	8:55:14	9:20:42	9:59:19
6:52:17	7:17:19	7:32:57	7:54:51	8:17:16	8:27:54	8:39:20	8:55:22	9:20:44	
6:52:17	7:17:22	7:33:13	7:55:13	8:17:24	8:27:57	8:39:20	8:55:25	9:20:54	
6:52:31	7:17:22	7:33:36	7:55:35	8:17:28	8:27:59	8:39:21	8:55:50	9:21:55	

(source: Cachon and Terwiesch, 2009, page 130)

This shows an example of call arrivals over a certain time period. This is an example of data that I need to collect for my analysis later on. It may not be necessary to collect all this data by hand, since such data are most likely automatically recorded in call centers. So a table like this can most likely be downloaded from the call center's datasystem. If I do this, then this data is seen as secondary data.

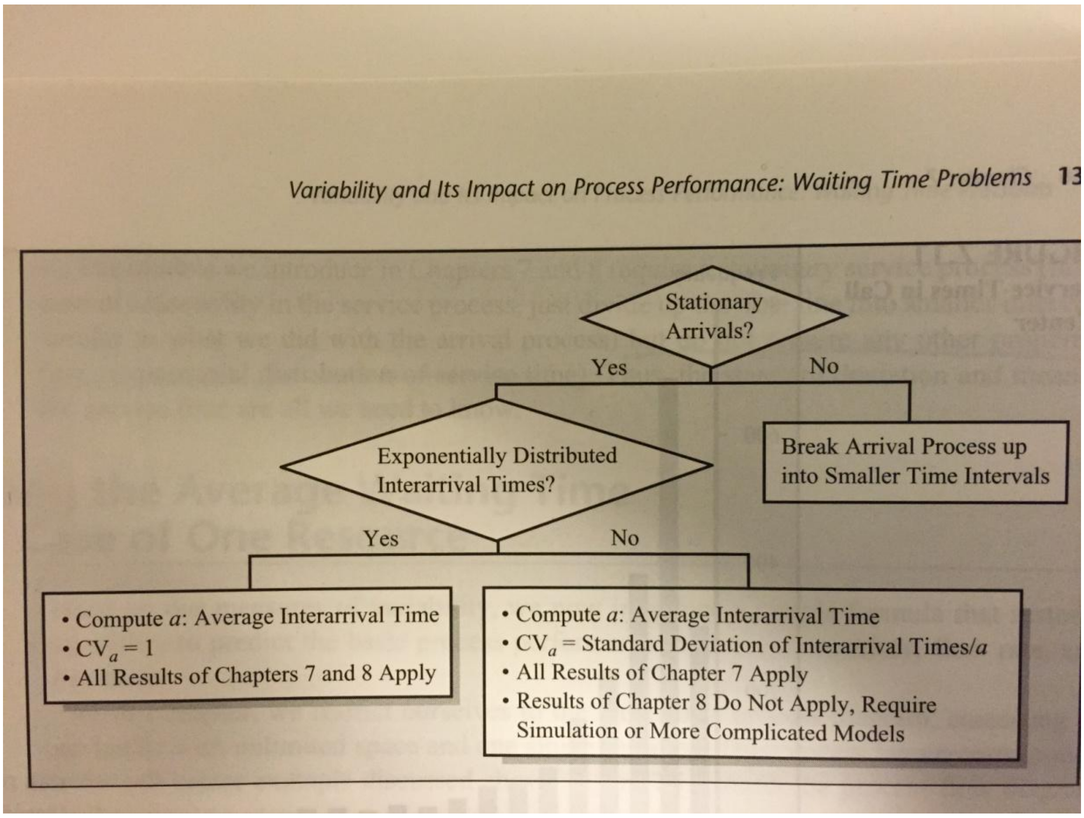
Information relating to the arrival process is required to do the performance analysis of call centre efficiency that will be carried out later on. It is important to collect data about the arrival (demand) process because it will be used to find the interarival times. And this is used to measure the variability of the arrival (demand) process, which has an impact on the calculation of the performance measures.

Data about the service times are also important to collect. Service time variability (from supply side) also affects the calculations of the performance measures.

Some secondary data that I need to collect:
- Wages per hour for agents.
- Number of call centre agents used

Data analysis:
The collected data must be analyzed before using the mathematical queuing models. Since call arrivals (demand) will function as a variable in the queuing models. The queuing model gives an mathematical representation of the inbound call centre queue's state. Based on a selected queuing model, I will calculate key performance measures. It is important to analyze the arrival process (demand) because it (its behavior) has an impact on the calculation of the performance measures.

- The collected data on call arrivals (demand) will be used to calculate ***standard deviation*** of interarrival time (definiton of interarrival time will be given in literature part) and ***mean*** interarrival time. This can be done through excel. These two values can be used to calculate coefficient of variation of the arrival process (detailed definition of this will be in literature part) which measures the variability of an arrival (demand) process. This value (coefficient of variation) will impact the calculation of the performance measures when I calculate these later on in this thesis.
I would like to analyze the collected data of the arrival process in the form that is suggested by the book "Matching Supply with Demand: An Introduction to Operations Management (2009) by Gerard Cachon and Christian Terwiesch" in chapter 7:



(source: Cachon and Terwiesch, 2009, page 135)

After that use queuing models to do the performance analysis and calculate the performance measures.

As explained earlier, the collected data will be used to calculate variables that describes the current performance of the call centre operation. The performance measures that will be calculated through analyzing the collected data, will be used to build the queuing model and through this, I can give a performance evaluation with the intention to find the best possible combination of changes to the values of performance measures that gives optimized service level and costs in the inbound call centre's queuing system.

Project plan:

After my first meeting on 15. December with chief operating officer Rune Lonkemoen from Proffcom, he told me that he is going to contact a couple of call centre's that are suitable for my research question. He later confirmed in an email that he has contacted them and waiting for reply and will forward it to me as soon as possible. After our meeting he sent me a couple of useful documents with calculation models like a Erlang C calculator.

I myself have contacted some call centers and waiting for reply. My first task after establishing contact with a company and getting confirmation that I can write for them, is to plan how data collection will be conducted, and start the process. Rune Lonkemoen told me, once I get contact with a company, go gather all necessary data/information and bring them to me in Proffcom so that I can assist you in analyzing the data. He said during our first meeting that he can assist me with the theoretical part. The kind of companies I am targeting are the ones where waiting time is crucial for customer satisfaction. Once It is clear which company I am writing for, I will give a presentation of the company in the introduction part and update research question. My main goal for now is to establish contact with company. Then try to understand how the call centre is set up and then map it though a queuing system.

After I have submitted my preliminary thesis, I will continue to extend literature review and theory, and come up with a theoretical framework.

I have also considered contacting call centers abroad like for example in India. If I am not able to get contact with call centers in Norway. If it's not possible to do queuing theory research on a call centre, then I will possibly turn to other areas where queuing theory can be applied. Like for example, queuing in airports, hospitals or queues in shops or in traffic.

Future time disposition:

This is a tentative schedule, changes might come to it.

Activity:	Date:
Find a call centre to write thesis for, and get confirmation from them.	January 16-25
Work on literature review and theory, extend it.	January 16 -
Hopefully get contact from a call centre and set up a meeting. Or change area of queuing theory application to something other than call centre.	January 25-30
Finish theoretical framework	February 1-20
Secondary data collection	February 25 - April 30
Primary data if necessary	February 25 - April 30
Processing data. Applying relevant theory to data, data analysis and interpretation.	March 26 - May 30
Develop a optimized model for the call centre performance.	Mai 1- June 1
Thesis writing	March 1 - June 30
Finished first draft	June 1-30
Write final draft	July 1-30
Supervisor reading, after that editing.	July 25 - August 15
Submit thesis	1. September

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