Performance Evaluation of Computer Systems

Prof. Krishna Moorthy Sivalingam
Department of Computer Science and Engineering
Indian Institute of Technology, Madras

Lecture No. # 04

Case Study: Selection of Techniques and Metrics

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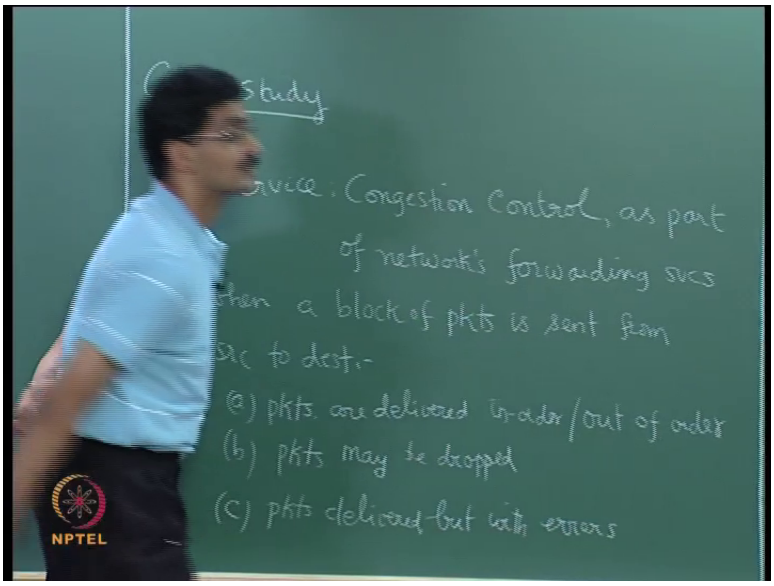

Last class, we are talking about a performance evaluation metrics of performance evaluation and so on. Let us look at one case study right for try determining to some common metrics. So, the system that we are looking at is comparing a set of congestion control algorithms; congestion control should be familiar, I should not be explained that you, background say networks is preferably there. And so I have a set of links, which make up a path, and there are several intermediate routers along this path from source to destination, and the routers can forward the packet or sometimes drop the packet and so on. And then in this networks system, we are trying to look at how congestion can control be better support.

Let us three or four systems which you want to compare. So the objective or the service of the system is congestion control is the service offered, and in general part of as part of forwarding services. So, as part of the networks…

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Packet forwarding services, in general networks forwards packets, but sometimes it wants to be more intelligent, when it is forwards packets therefore, there is some mechanism for the congestion control. And when you transmit a block of packets, so when a block of packets is sent from the source to destination three things, few things can happen in terms of the outcomes, some possible outcomes in such a system; so, one is the packets are delivered in order or out of order, that is true in any packet of system, because packets can be switched out of order therefore, there is one possible outcome. Then there are some packets are to be drop by the one or more of the intermediate routers. So, packets can be dropped…

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Anything else, any other outcome, so either delivered in order out of order or not delivered at all; yesterday we saw one more option or friday we saw the other option that the packet can be then no delivered, but error. So…

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That is your three options.

So, this is the basic definition of a system, because we are trying to see how we can be sort the methodical find to list out all the potential performance parameters for a given system.

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But as far as the service is concerned, because the user uses the network to send packets from point a to point b. At the end of it, the packets could be error, because of link errors either it is drop because of buffer overflow or because of wireless link errors.

Which will be found this only congestion control?

Service as part of the network probability services, so I am trying to compare different congestion control mechanisms, where forwarding is the basics service on top of that I am adding this congestion control as an extra service, and as the congestion control does not really have anything do with erroneous packets.

But still as part of forwarding sometimes errors can takes place; congestion control will usually deal with result in one of these two, whatever mechanism use packets can be out of order because the congestion control mechanism decided to hold packet and some other packet ahead of it or dropping is simply because a buffer stack full or closed full, but as a network service, these are the possible errors. So, now we should try to come up with the set of possible performance metrics that will try to capture the performance of the system.

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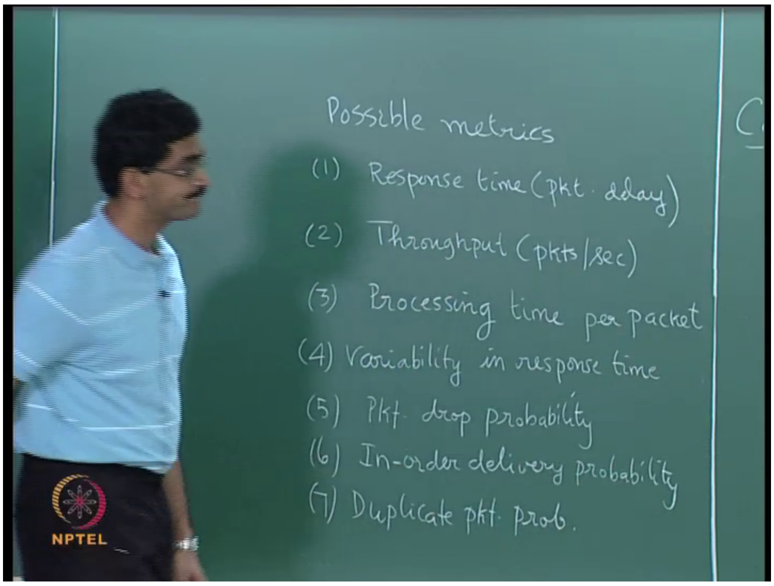

Possible metrics (no audio from 05:08 to 05:18) with this, we have some of these we have seen in the advance networks course to high, but some not, but you have taken network cores. The common metric that we know as in the packet delay, so the response time or delay or the packet that is the high level metric. Some of these are local to the user; some of these are global to system as such. So, then the metric in we are get throughput, we can look at router and look at how many packets per second is the router able to handle that is the system throughput or per router throughput; wherever you measure you can look at every router and look at the throughput of each routers or just look at the entire system and say an average, so many users started sending packets I looked at number of delivered packets and therefore, the total capacity in terms of packets delivered is x number of packets measure there something that we can do at various levels, so their granularity of this can be varied.

Then other things processing time per packet, this is algorithm dependent; it depends upon the forwarding algorithm, as well as the congestion control algorithm; that will essentially come as we look at other things. Within the response time also we can look at just the main of the packet delay or sometime also variance, variability in terms of packet delay. So, we can look at this, we can make an event, so variability response time which is technically related of this one it is not a separate metric, but just to be in the book variability in…

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Then others are packet drop probability and so on. So, it is the fairly straight forward exercise; so since packets are drop, I need to measure what is the fraction of packets are not appear?

There is one question.

(( )) is to be use to received per second, we have the sender generates packets can be stored in the network dropping. The network depends upon the proper capacity depends upon the processing time, operating time and so on. Ultimately measure the total number of delivered packets; we look at the total delivered packets as to that you will have to define as what you throughput measure as packets delivered per second.

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So, will we go along? So, these are higher level than we look at in order delivering out. I can simply count all the packets sent and then see where they all set in the same order, if it is then a record there is in your probability otherwise I will also record. That is out of order then your probability.

(No audio from 09:14 to 09:26) and sometimes the network also deliver packets twice. At this same packet can be delivered twice because what happens is this user sends the packet it gets buffered and then it is sleeps in the buffer for a long time and then this user times out, in sender times out since the packet all over again. So, you might have duplicate packets being sent. So, that is your duplicate packet probability.

(No audio from 09:48 to 10:01)

Counting to the throughput point of it was. That will have to deliver define a throughput as saying.

That you will not counter. So, only unique packets your throughput from forwarding point of view. You will not care you only say I handle. So, many packets when it goes to the destination can say only these are. So, many unique packets where at to delivered in that to use that for the throughput measure. So, that is you have to clarify when you write throughput definition that it is only unique packets will be considered whereas, the router way itself will not know at the router level will not know whether a packet is duplicate or not because TCP sequence number is what differentiate that the two packets. So, TCP level that this same packet therefore, I will not send this packet for…

(( )) any forwarding algorithm.

True.

We are not means is any specific material for congestion control.

Fine let us see this something else for congestion control.

Other in terms of congestion control.

True. At the congestion these congestion control is looking like a rate hearing really make is not difference, but then that is looking to what is the congestion control algorithm do?. So, now we come into business of fairness. So, that is your congestion control can I actually coming we talk about fairness in the other class.

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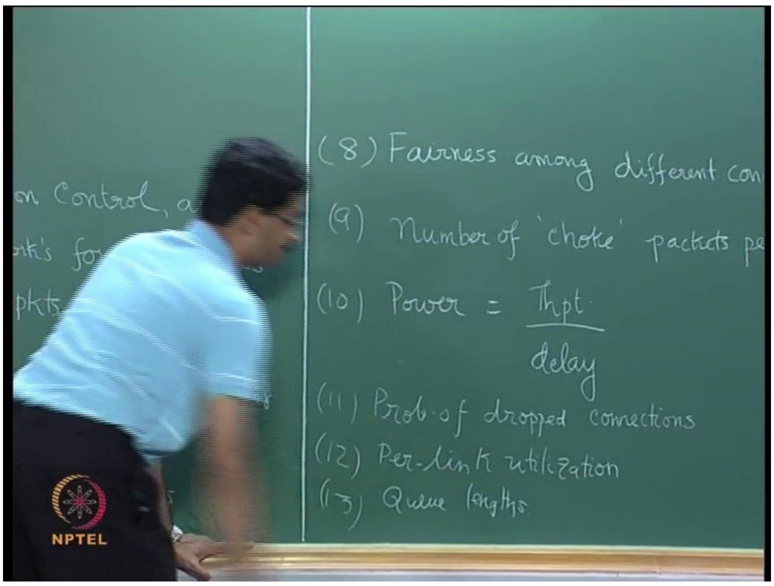

Let us go here…

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Know this is the network level congestion control algorithm. So, network level congestion algorithm what are different ways in which can try to control congestion at the network level, TCP level we know congestion window is there you manipulate that with you congestion choke packets can be said. So, then the different algorithms how do they in what order is they who we will have to write this later on have who gets more choke packets. How do you differentiate between the different connections will one connection get more choke packets then the other one, in which case it will have just throughput. If I look at this throughput as I can do this per connection. What is the number of packets delivered per connection and then look at the different throughputs across the different connection that where fairness concepts.

Do all the connections entering the network get the same amount of bandwidth requested max win fairness, we will leave that for the moment, but depending on whatever they ask and so on. You able to get the required amount of bandwidth is it equitability shared among all the different connections. So, that is where the congestion control is specifically come into in terms of how you differentiate the different nodes in terms of how do you sent choke packets when that is one.

What other congestion control mechanisms possible one is explicitly sending choke packet it is from the router back to the source nodes, anything else?

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Something like leaky bucket algorithm or doing random only detects where random only drop, where you simply drop connections you drop packets from the even before the buffer gets full. Even is sometimes sent to drop the packets and that is mainly to trigger congestion control at the higher layer, but that is still question of which connections do you trigger these drops for there it is where again, we can look at the other things also.

So, you can look at what can we define in terms of packet drops; packet drop is set of more or less look at here. Like packet drop probability is coming in there and that is we can do their at the system level, at the router level or it the for connection level and then look at variations among the different packets. Packet drop probabilities and that is where your fairness also coming. So, packet drop is will be taking care of by their and other things are fraction of at the number of choke packets.

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So, that is to differentiate in terms of which connections get more choke packets, in which connections get less choke packets and so on.

The third mechanism that we use at the network level for congestion control is marking packets very simply marks the packets. We do not entirely drop it you, do not send the choke packet. We simply mark say congestion bit is a turned packets that goes to that our receiver then echoes in back to the sender. That is again more of gentle way of telling the network that telling the sender that there is congestion in the network. So, what is the marking algorithm? that can also differentiate and how the sender response to the mark packet is up to the sending side algorithm that is now at higher level it is not necessarily at the network layer. Network layer more of the passive observer that tells you are that there is congestion.

Let us the upper layer decides this is set of standards way in way which look at all the possible outcomes of the system and then for each of the outcomes start interesting what are the critical parameter and so on. Sometimes what people try to do is they try to combine some of these metrics together, see what happens is when the load is very light delay is going to be fairly low; throughput is also going to be proportional to load. So, as your then as it load in the network increases throughput also start increase, more packets start getting generator, more packets start getting delivered and therefore, throughput is also high.

Which means the queue link also start increasing and therefore, your over all delays is also going to be high. Sometimes people have tried coming up with their own metrics which is say power is something that this and company had that proposed. As the unitary metric to look at the ratio of throughput delay is sometimes also look at a different metric. You compare two different systems in terms of… So, called power why they call it power will that is now look at it right now, but simply it is a ratio that it compare as the throughput of given system to the average delay of the given system. So, this throughput is the benefit, delay is the cost, it is benefit to cost rate ratio is what you trying to compare.

So, you would like to have a system which has high throughput and low delay which means the power value will be higher. So, because you laugh and find that will be two algorithms one which will sacrifice you all is the delay throughput rate of this always there. When you want to compare this kind of trade of then you would like to look at some other metric that might or might not help you, but trade depends upon the system. That you measure that I do not see power vary of used lot him today's paper, but that is another way of looking at it is an artificial metric. So, these are all several natural metrics that we can think of that is more of metric. They rise to combine the different metrics together and have a single metric give you different views of the system itself.

Packets we can all together drop connections also.

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Through us can something like percentage of connections drop?

You can do that? So, this is your probability of dropped connections that is an extreme, but that require some information in the typical i p flow. You will not know what are that these are packets going from the source to the same destination. There is some other n p l s label and so on, where you say that amount ignore all packets from this particular label because it is use to much of capacity or some v c i d or flow i d is there then you can do that otherwise simply based on the source address you will not know even source i p destination i p you need of the port numbers also. Just the multiple duple that there are look at portable at look at before you start dropping connections, but anyway in theory you can do that if you want to differentiate.

You want to have one particular connection which is over that network at any too many packets then you would like to do drop these particular connections and so on. It is fix a label. You can look at the label and then simply say drop all packets on this particular it is like your right there. Can also do that, but rate has the probabilistic you can dropping packets at a time from the queue, but you can simply say that I am not going the forward packets I am not sure, but it used anywhere, but in theory you can do that at the forwarding tables. You say that all packets from this flow for the next one hour I am going to ignore either because a firewall reasons of whatever it is that your think that this particular connections is taking too much of resources.

Then you can use that is the reason to temporarily block the connection and that we will lead to upper level connection drops anyway. So, other thing is your not look at here is utilization of the link concepts. How are the different links utilized because one of the implications of congestion control and of routing is, if I route all the packets on one particular segment of the network can be other part of the network is left and utilize then you have high utilization are there, but fairly low utilization on the other side of the network.

So, that is again not desirable. So, utilization load balancing of resources use to all those things to have their. So, one can look out per link utilization is there and ideally you should be using all the links uniformly, but depends upon the traffic flows in the network. So, there is no real control over that, but within these different algorithms you want to see one is better utilizing the network in more load balance to they then other algorithms anything else.

Any resource like buffer or CPU.

So, you can look at average that is what the queue lines, queue length is also another metric that is more of a final delay metric that you want to look at sometimes you want to explain why some delays are happening, then you go look at that is the secondary metric is that is the queue length distribution and for this particular algorithm the queues are very long and therefore, did not that also we can look at inside the problem.

(No audio from 20:41 to 20:54)

Important factor for congestion control.

They use it to make decision you are say.

If you look at (( )).

Some that is actually an input parameter algorithm. So, the other cases it is not, where it is applicable you do look at queue length distribution. I think we and go further, but will start we can say what is the impact and quality of service because we are not only talked about how to these algorithm differentiate with respect to different requirements and so for that is essentially what you would like to do. So, when you sit down and look at a system, go through the system in detail then always just looking at throughput and delay are just one metric and that is basically not adequate that is what this exercise tries to tell. As there is the section on common metrics response time through put bandwidth and so on which I think more or less we have covered with this example I want to go through that section.

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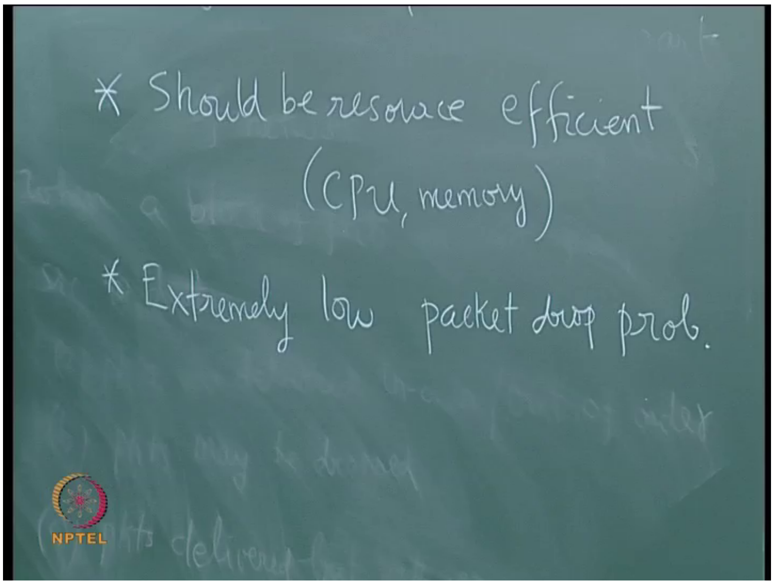

There is one last section in this chapter, which is on setting performance requirements.

(No audio from 22:03 to 22:20) So, sometimes in a define in your system to be built you would like to specify some in terms this should be the number of connections this router should be able to handle. So, many connections or this algorithm should be able to handle such a large input size. Those are specification at one and that is used as the basis for the implementers if you are sitting in a company giving a contract to some other company. You should be able to tell what your requirements are and you can be very vague on those things you should run well run very fast. Those are your typical requirements runs fast with least amount of resources then you just give that and the client breaks a head over. What is this mean are the interpret of they want; this is the best we think is fast and so on.

So, it is easy to be vague on the specifications, but what this tries to tell you is that when you set the requirements. So, these are things that we measure from a system has to what is the effect of it, but sometimes you want to just set some goals for a system. Before you start telling somebody else to actually go on that system, and I will say some of the bad examples or poor example should be resource efficient. So, the resources can be CPU memory and so on (no audio from 23:37 to 23:52) or it can be even vague extremely low, let say packet drop probabilities. So, these are things that you would rather word and these days it is fancy it is everything should be energy efficient. Whatever that may energy efficient this energy efficient this green that on whatever; that means, we do not know it is going to be 10 percent lower than current system. If we want to define a new vehicle or battery and solar radius should be able to come out and say should be less than current consumption should less than about your 10 percent compared to your current systems.

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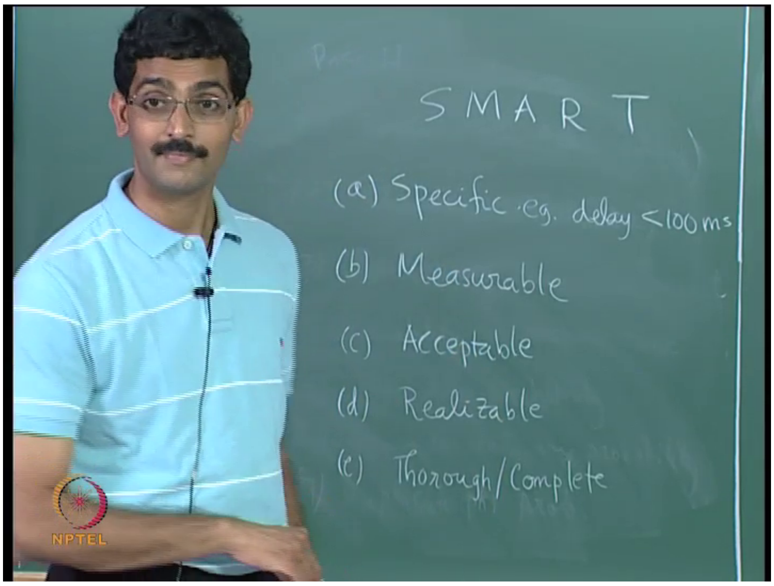

So, that is why the author has clay has as a put together this, so called smart set of requirements. So, your requirement should be very specific in some cases you can be very specific some cases you cannot be very specific. So, in the case of voice packets that is sent on the voice video stream. When I send the packet you should be delivered there is some amount some delay that is there 150 milliseconds approximately before thus after which the packet is basically used so, be very specific. Example, delay less than 100 milliseconds. One can say that, but still that is not very specific you think about it when you say delay less than 100 milliseconds what delay average packet delay or worst case packet delay, because worst case packet delay can be very large average is 100 worst cases could be say 2 seconds also.

These things are easy at specify then realizable, but anyway you should have there is some find balance we have to trade that. So, should be specific with something and also something that is measurable. That is important if I tell the delay I can measure delay and I can tell you see in my experiments I found that delay is less than we have the limits consistently most of the time or 90 percent of the time delay is less than 100 millisecond. So therefore, I met your requirements and if you are not specific in your requirement then measuring is also going to be very hard. Sometimes the specific the user may be saying that very easy to you say how did you define easy to use you do not know and even if you look at your Voice over IP calls today. There is something called mean opinions score that is actually also almost subjective evaluation, since subjective criteria then objective one.

But you know that is about the best that we have today. So, it is measurable, but it is kind of vaguely measurable. How do you define quality of wise on voip call? You say your landline is fail crystal clear therefore, that is fail your cell phone is support 3G and these are again not really measurable, it is not directly taken from your signal to noise ratio measure it is more or less people say that I think this is good enough and so on. As to have your rate your songs on your one to five stars you can call it measurable, but it is more of a very subjective criteria then acceptable.

(No audio from 27:27 to 28:16)

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When you set the requirements of the system yes one is simply measuring. So, for example, queue length may not be able to say anything do you want to see queue length keep it always under 50 percent. If you say queue length under 50 percent than it means that your link capacity should be higher. Basically you should not operate then system at load which you need to more than 50 percent of queue length. So, some of it depends upon your input parameters for the system also, that is in terms of design of the system itself. If you want to design a system where the queue length will never be more than say you know 500 packets you have provision for 1000 packets, but you want to make a system never really operates that more than 500 packets queue length then that is you have to provision it by controlling the load or controlling the system parameters.

We saying that I would the system parameters are what say I have 1 per second link or 1 mega byte per second link, where the workload parameter these two things you would controlled make sure that these requirements are met or you tell a set of operational parameter with say, if you are within these ranges system will have these cannot.

Something like making the technical queue or (( )).

Yes, though if you are able two probably that you seen and so on. I will say that the system should be support 10 mega byte per second of traffic, and that solve it will say what is it, where is it come from that is not always specified than we will have to go and guess. How much of it is voice, how much of it is data if you say delay should be less than 10 milliseconds then it is not possible for all kinds of traffic to get 10 milliseconds. Some times that is comes later. So, when you build systems for a customer's say call drop of it should be less than it will building a system that is delivery supporting say are cellular network. In this say you should be no more than one call every million calls dropped.

When the user tries to make a call that is good well line specified that is where some of the series yes, specific it is measurable is that acceptable and realizable. Those are something that you through in the sense that we should consider all kinds of metrics there it make the system essentially complete and there are a various aspects. This is the first three chapters of just part one of the taken text book more of generic setting. The stage for what you would like to do in terms of what are the some of expectations?

So, forth questions why the acceptable do.

I will acceptable to the customer to the own implement that both here. You know sir, you realizable that…

I know realizable they have and check that the better explanation that the recent we will differ that and come back to that this few seconds. We will just look at realizable is as if you going to set realistic goals acceptable will come back and clarify on that.

(( ))

Whether the goals are issued acceptable also seems to be the same thing. So, they will come back fixed plains to...

Whether these able to expect them are the port of is it is. Where let us possible where let may calls more to the rare, but of the customer.

Yes, but minimum is who is define in the client comes it and says somewhat to the support the million customers then the client will accept that if you give anything less that the client will is not going to accept that. But give the you as a developer should know at designer should know that the this is actually achievable or not realizable achieve the come it you that like that is just to acronym have probably acceptable came on, but when will take look at that and deal with the part one .

So, we move to part two now. So, the book part is not our part two is going to out of order with these what book is trying to do. In fact, the book whatever I want is in chapter 20, 29. So, some part is here some parts are elsewhere. So, the little bit of jumping in the book, but you have this book is more of for reference. Sometime these textbooks which are all references some chapters that we simply you can directly go into their chapter without looking at some of the previous chapters. So, now we are going to start looking techniques tools. Actually help us look at the mathematical modeling of thing. So, that is part one. So, we see set there are three different techniques mathematical techniques as well as simulation and implementation.

So, you look at some mathematical techniques that will help us understand the performance, analyze the performance of some subsystems, and that will not be exhaustive, you will not know all the possible techniques, this is more like CS110 or basics of programming. We know some a basic amount of programming, but as you look into more and more research articles are the keep for a performance, conference and journals will find that more and more company performance evaluation method all is that keep coming out. So, for now we will look at the most common once that can help us everything all. So, we will start with looking at Markov chains and processor would before I go there, I think we need brush up of some of the basics of random variables and some of them commonly used variables. And again our statics and probability little bit of that, we will try to.