IIT Madras

ONLINE DEGREE

Computational Thinking
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Concept of concurrent execution using polling and pre-emption

PROF. MADHAVAN MUKUND: So, let us go back to a class teacher. So, we had done at some point this problem of allotting say prizes we want to find the best student or the best 3 students. So, now presumably this job is delegated to…

PROF. G. VENKATESH: The class teacher.

PROF. MADHAVAN MUKUND: So, the object, the class teacher is…

PROF. G. VENKATESH: We do not need to know

PROF. MADHAVAN MUKUND: Tell the class teacher, give us a top 3 student, or a top 1, top student. Let us say this is a top student. So, then the class teacher will has created we assume, there is already got the subject teachers, who…

PROF. G. VENKATESH: We create or they create

PROF. MADHAVAN MUKUND: Yeah, or they have to create it, to get the marks.

PROF. G. VENKATESH: Okay.

PROF. MADHAVAN MUKUND: So, we have the class teacher as before.

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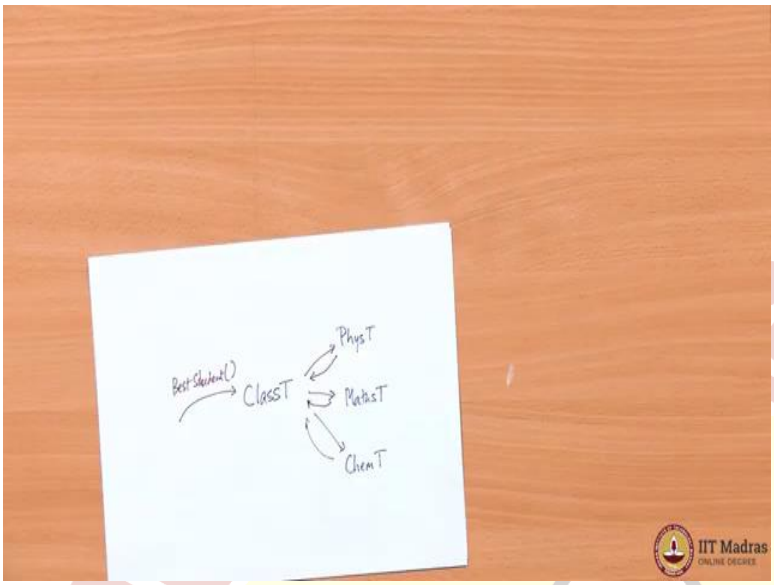

PROF. MADHAVAN MUKUND: And then we have these different teachers, the physics teacher, maths teachers, these are the inside, internal objects. So, we ask somehow to contact this person, the message saying best student.

PROF. G. VENKATESH: So, class teacher will say to physics teacher to give you the best student.

PROF. MADHAVAN MUKUND: Yeah, so the class teacher will have,

PROF. G. VENKATESH: Maybe, he will ask the physics teacher, chemistry teacher, math teacher,

PROF. MADHAVAN MUKUND: Because we decided that somehow it is some combination of the individual marks and the total marks. So, there is some formula,

PROF. G. VENKATESH: Something.

PROF. MADHAVAN MUKUND: Some formula that the class teacher will

PROF. G. VENKATESH: Have a figure,

PROF. MADHAVAN MUKUND: We do not need to know. We just need to know name. So, the class teacher but has to know this. So, class teacher might ask maybe the top 3 in each, because the top student may not appear and then do something. So, it will ask some information here. We will ask, some information here.

PROF. G. VENKATESH: Okay,

PROF. MADHAVAN MUKUND: And here, but now, we have to decide, what happen.

PROF. G. VENKATESH: Get the result.

PROF. MADHAVAN MUKUND: And then all these will answer. So, this guy will give an answer, this guy will give an answer, this guy will give an answer.

PROF. G. VENKATESH: So, question here. So, what does it do? Class teacher will call the physics teacher?

PROF. MADHAVAN MUKUND: And then what is it like,

PROF. G. VENKATESH: It is an object? So, we will call the physics teacher object to do something, pass it parameters,…

PROF. MADHAVAN MUKUND: And get an answer.

PROF. G. VENKATESH: Get an answer. Meanwhile, what is class teacher doing?

PROF. MADHAVAN MUKUND: Well, so far, nothing. So, this is

PROF. G. VENKATESH: Waiting,

PROF. MADHAVAN MUKUND: Waiting.

PROF. G. VENKATESH: So, after doing that, it will come back to maths teacher.

PROF. MADHAVAN MUKUND: Yeah, then wait, maths teacher will come back. Then,..

PROF. G. VENKATESH: What well the physics teacher is doing something.

PROF. MADHAVAN MUKUND: Maths teacher is idle.

PROF. G. VENKATESH: Maths teacher is idle.

PROF. MADHAVAN MUKUND: And the class teacher is also idle. So, only at any given time, only one of these 4 guys is working, which is not very, does not seem to be a very optimum, efficient way of…

PROF. G. VENKATESH: Real life.

PROF. MADHAVAN MUKUND: Yeah, that is right. Because…

PROF. G. VENKATESH: We do it like in a class teacher will tell the physics, chemistry teachers.

PROF. MADHAVAN MUKUND: Exactly.

PROF. G. VENKATESH: So, they will do their job and they will give back.

PROF. MADHAVAN MUKUND: Exactly. We will not be expecting the physics teacher to finish collecting the physics marks. Give us the answer. Only then…

PROF. G. VENKATESH: Today I call, Monday I call physics teachers say Monday. Physics teacher give you the best student, so I will wait till end of Monday. Then on Tuesday, I will call her. On same day on Monday, itself, I will call physics teacher. Get me your best student, chemistry teacher get me your best student, maths teacher get me your best student.

PROF. MADHAVAN MUKUND: Okay. So, now,…

PROF. G. VENKATESH: In evening, I will collect all the marks. good.

PROF. MADHAVAN MUKUND: Yeah.

PROF. G. VENKATESH: Something like that.

PROF. MADHAVAN MUKUND: So, then how we have to go back to them at some fixed time and say,…

PROF. G. VENKATESH: But that means what? When I call this physics teacher, I am not calling What am I doing?

PROF. MADHAVAN MUKUND: Yeah, because I am not doing what we had said earlier. So earlier, we said that when we have this kind of a procedure call it this is what we do, we kind of say.

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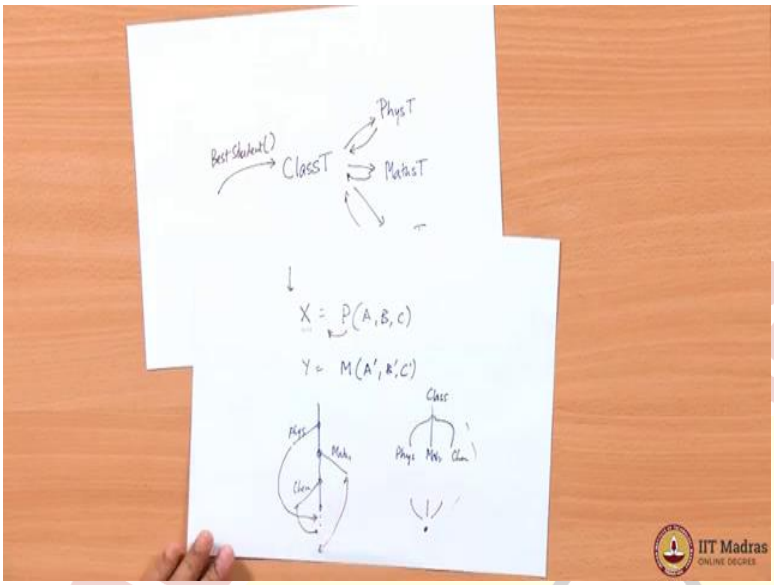

PROF. MADHAVAN MUKUND: So, we said some x equal to P, A, B, C, or something like this. If we call then at this point, we are executing this thing as pseudocode or something will come here and then we will wait. So, this value will be effectively the answer. So, we are now waiting. But Now supposing we want to proceed so, say this is the physics marks. And now I want to ask some questions about the maths marks. So, we might give some different.

PROF. G. VENKATESH: So, I want to do one thing. I want this as too many things going on inside. I want to unpack it.

PROF. MADHAVAN MUKUND: Okay.

PROF. G. VENKATESH: So, one is that first I called P A, B, C. And then P A, B, C gave me the result.

PROF. MADHAVAN MUKUND: Yes.

PROF. G. VENKATESH: Meanwhile, I am waiting, then I took the result and put it in X.

PROF. MADHAVAN MUKUND: Yeah.

PROF. G. VENKATESH: Cannot we separate these two things? I first called P A, B, C.

PROF. MADHAVAN MUKUND: Yeah.

PROF. G. VENKATESH: That I, I do it at one step. Then I wait. Then P A, B, C, gives me the result, then I put the result in X, I want to,

PROF. MADHAVAN MUKUND: Separate it out into these units.

PROF. G. VENKATESH: Because the reason I want to do that is because if I call P A, B, C, then I do not have to immediately wait and get the result. Meanwhile, I can to do something. I can call M A, B, C.

PROF. MADHAVAN MUKUND: Correct.

PROF. G. VENKATESH: Something like that, that is not good

PROF. MADHAVAN MUKUND: That is true.

PROF. G. VENKATESH: I give the task. I am not waiting for the result. Give the task then I go and give the task to somebody else. Then I give a task to third person.

PROF. MADHAVAN MUKUND: And then I wait,

PROF. G. VENKATESH: We wait,

PROF. MADHAVAN MUKUND: For some point have to wait. Because I do not have any more tasks to do, I like at this.

PROF. G. VENKATESH: I do not have…

PROF. MADHAVAN MUKUND: I have to wait for all these 3 to proceeds. So, there is a…

PROF. G. VENKATESH: Then I go back and check with the first guy who finished. He says no, I am not finished. Okay. Second guy, are you finished? Like that, I can keep going?

PROF. MADHAVAN MUKUND: So, you keep going around. And as one by one, they finished. They will give you the answer.

PROF. G. VENKATESH: Do not keep bothering me. Come back after some time. So, wait, okay. I say okay, I will come back after one hour. After one hour, I will go back and ask this guy. Hey, you told me one hour, are you done? No

PROF. MADHAVAN MUKUND: Yeah, correct.

PROF. G. VENKATESH: This is way we do, normally it is how we do it.

PROF. MADHAVAN MUKUND: Yeah.

PROF. G. VENKATESH: Which is crazy. Because this is not like procedure call.

PROF. MADHAVAN MUKUND: This is quite different from the way we have been thinking about procedure, because we are not getting the answer.

PROF. G. VENKATESH: Immediately?

PROF. MADHAVAN MUKUND: Not just immediately, it is not that we are holding on until we get each answer, and then proceeding to the next step. So, we have multiple things happening at the same time.

PROF. G. VENKATESH:

PROF. MADHAVAN MUKUND: Yeah, at same time. And,..

PROF. G. VENKATESH: So,..

PROF. MADHAVAN MUKUND: We do not also, whether the Maths teacher will return.

PROF. G. VENKATESH: So, this is the first time, we are seeing this, so far, it looks like so far, there is only one thing that was going on.

PROF. MADHAVAN MUKUND: Exactly. That is right. So, if you ask me what I am doing, if I give you some procedure, or I give you some complicated computation, and I stopped it, and I asked you now, at what stage of the computation are we, then you can tell me we are at this point.

PROF. G. VENKATESH: This place.

PROF. MADHAVAN MUKUND: This place in the computation. And then you can also tell me at this point, these are all the values. So,…

PROF. G. VENKATESH: Which could be in the main procedure, main thing, or it may be and

PROF. MADHAVAN MUKUND: will be. That I have jumped to…

PROF. G. VENKATESH: Call a procedure.

PROF. MADHAVAN MUKUND: Call a procedure. So, I have suspended this come here. And inside

PROF. G. VENKATESH: Inside the procedure,…

PROF. MADHAVAN MUKUND: Inside the procedure, and I can take a kind of snapshot of that and tell you I am at this place in the code.

PROF. G. VENKATESH: So, at any given point in time. I am at exactly one place in the

PROF. MADHAVAN MUKUND: In the…

PROF. G. VENKATESH: Code.

PROF. MADHAVAN MUKUND: Yeah, sequence of things I am planning to do. So, I could be going around back and forth. I could be doing iterations and all that. But I am always at a fixed place.

PROF. G. VENKATESH: I know where you are.

PROF. MADHAVAN MUKUND: I know that,…

PROF. G. VENKATESH: But here it is no like that.

PROF. MADHAVAN MUKUND: Here, multiple people are active at the same time,

PROF. G. VENKATESH: The guy you called parent, class teacher is doing something

PROF. MADHAVAN MUKUND: Yeah, physics teacher.

PROF. G. VENKATESH: Called the physics teacher gave him a task, physics teacher started doing something.

PROF. MADHAVAN MUKUND: Maths teacher, she is doing something else.

PROF. G. VENKATESH: Maths teacher, is doing something else. Chemistry teacher is doing something else.

PROF. MADHAVAN MUKUND: Yeah.

PROF. G. VENKATESH: So, each of them have their own thing.

PROF. MADHAVAN MUKUND: And they might finish at different times.

PROF. G. VENKATESH: If you ask, wherein the code, are you? Where in the execution are you?

PROF. MADHAVAN MUKUND: We will have to point to these 4 or…

PROF. G. VENKATESH: 4 places.

PROF. MADHAVAN MUKUND: 4 places.

PROF. G. VENKATESH: Class teacher will be somewhere.

PROF. MADHAVAN MUKUND: Yeah.

PROF. G. VENKATESH: So, there are 4 places of execution, instead of 1.

PROF. MADHAVAN MUKUND: Yeah.

PROF. G. VENKATESH: Oh.

PROF. MADHAVAN MUKUND: So, in a sense, it depends on how many of these objects have been activated.

PROF. G. VENKATESH: So, this is what parallel, is parallel?

PROF. MADHAVAN MUKUND: So, it is not really

PROF. G. VENKATESH: Parallelism.

PROF. MADHAVAN MUKUND: Parallel. Yeah, it is parallel in one sense that things are happening in parallel. But usually, in computation, we distinguish…

PROF. G. VENKATESH: Between parallel.

PROF. MADHAVAN MUKUND: Yeah, so parallel means that you explicitly tell…

PROF. G. VENKATESH: 4 computers are there,…

PROF. MADHAVAN MUKUND: 4 computers, you break up the task into 4 things which can be done separately, and you tell them okay, you do,

PROF. G. VENKATESH: But in this case, there are 4 computers, not class teacher, physics math teacher is a real life.

PROF. MADHAVAN MUKUND: Yeah. But …

PROF. G. VENKATESH: When they are executed in a computer,

PROF. MADHAVAN MUKUND: Yeah,…

PROF. G. VENKATESH: Maybe one computer only, when we that…

PROF. MADHAVAN MUKUND: Yeah, okay. So, for example, supposing I had only 1 subject like maths, supposing not the marks, supposing I want the exams corrected. And I had 3 people there, I could give each of them one-third of the exam papers. And say you correct it.

PROF. G. VENKATESH: I see.

PROF. MADHAVAN MUKUND: So, now I have broken

PROF. G. VENKATESH: Give it the exam paper, so in the 3 parts

PROF. MADHAVAN MUKUND: Yeah, so I know that the first-person's correction is independent. I mean, they are marking their papers from beginning to end. It does not depend on the second person. So, this way, I break up the job into 3 different things. But they are all the same type of thing. So, this is usually how we speed up things in parallel by breaking it up into multiple copies of the same thing. Whereas here, actually, okay, now we are asking the physics teacher to compute some best students in physics, math teacher to compute the best student. Now, it may be that in physics, there were some experiments, there were some, you know, exams. So, they might give some weightage to experiments. So, they might be doing some complicated calculations to figure out that. Maths, there might be a different way of computing the best may not just be the marks. So, they are doing different things. And simultaneously, so this is concurrent, I would say, concurrent,

PROF. G. VENKATESH: That is what it is called concurrent.

PROF. MADHAVAN MUKUND: Concurrent.

PROF. G. VENKATESH: Concurrent.

PROF. MADHAVAN MUKUND: Concurrent, meaning they are happening at the same time, but not necessarily same thing. They are not doing.

PROF. G. VENKATESH: Okay.

PROF. MADHAVAN MUKUND: They are doing different things but at the same time,

PROF. G. VENKATESH: For concurrency,…

PROF. MADHAVAN MUKUND: Concurrency.

PROF. G. VENKATESH: So, we have a, so concurrency means that unlike what we had earlier, where there was only one place, one point of execution, right one place, as the whole thing where you are? You can tell me exactly. Concurrency means that is not one place, there are multiple.

PROF. MADHAVAN MUKUND: So, there are multiple parts are active and each is at a different….

PROF. G. VENKATESH: Different point.

PROF. MADHAVAN MUKUND: So, I have to tell you how many things are active and each one. So, each one is doing something in a fixed way, but more than one is active.

PROF. G. VENKATESH: Bit confusing? Complicated thing about this concurrency,…

PROF. MADHAVAN MUKUND: Yeah, it is very complicated, I mean it. We know in real life also, it is complicated. So, if we ask something to be done, sometimes.

PROF. G. VENKATESH: You do it all the time and human beings are interacting in so many ways, concurrent only.

PROF. MADHAVAN MUKUND: Yeah.

PROF. G. VENKATESH: Real life is concurrent.

PROF. MADHAVAN MUKUND: Real life is concurrent. Yes. But the difficulty happens. When these 2 concurrent things interfere with each other somehow, see here, there is no interference. The physics teacher is doing something with the physics.

PROF. G. VENKATESH: Independently?

PROF. MADHAVAN MUKUND: Math teacher, so there is nothing really.

PROF. G. VENKATESH: They are not talking

PROF. MADHAVAN MUKUND: Yeah, so the class teacher is the only person who has to collect this information from the 3. The class teacher is only one.

PROF. G. VENKATESH: But he is a physics teacher does something which the math teacher needs?

PROF. MADHAVAN MUKUND: Yeah, then you have a problem.

PROF. G. VENKATESH: But here also there is something like the physics teacher has to give the result back to the class teacher.

PROF. MADHAVAN MUKUND: So now, if that gets confused with,

PROF. G. VENKATESH: See in this case, it was easy, because Physics you know, a math, class teacher was waiting.

PROF. MADHAVAN MUKUND: So, you know where to get her next answer is going to come from who?

PROF. G. VENKATESH: You know, but here.

PROF. MADHAVAN MUKUND: So here, as he said, we discussed 1 possibility is that you keep asking.

PROF. G. VENKATESH: Oh.

PROF. MADHAVAN MUKUND: Yeah, you poll them.

PROF. G. VENKATESH: So, every so much time, let us say every hour, you go back and ask the physics teacher, chemistry teacher, maths teacher,

PROF. MADHAVAN MUKUND: So, they do not actually give you the marks until you ask them for it,

PROF. G. VENKATESH: Unless you ask them for it.

PROF. MADHAVAN MUKUND: So, you give them time to do their work.

PROF. G. VENKATESH: So normally, the procedure when you call the procedure, the procedure and it finishes, returns the result.

PROF. MADHAVAN MUKUND: Yeah, it does.

PROF. G. VENKATESH: As soon as it finishes.

PROF. MADHAVAN MUKUND: because it knows you are waiting for that. You are kind of,..

PROF. G. VENKATESH: Yeah.

PROF. MADHAVAN MUKUND: Stuck.

PROF. G. VENKATESH: But here, the physics teacher may have finished, but cannot return the result.

PROF. MADHAVAN MUKUND: Yeah.

PROF. G. VENKATESH: Because, where do you return the result over?

PROF. MADHAVAN MUKUND: Yeah, because, you do not know,

PROF. G. VENKATESH: Waiting

PROF. MADHAVAN MUKUND: Where the class teacher has gone off somewhere else.

PROF. G. VENKATESH: He is gone somewhere else. So, what do you do now? So, you basically when you finish computation,

PROF. MADHAVAN MUKUND: You sit waiting for,

PROF. G. VENKATESH: You sit waiting for the class teacher come back…

PROF. MADHAVAN MUKUND: And ask you for the answer,…

PROF. G. VENKATESH: Ask you for the answer. Of course, if you are still busy,…

PROF. MADHAVAN MUKUND: Yeah, then you say…

PROF. G. VENKATESH: Busy

PROF. MADHAVAN MUKUND: Not done.

PROF. G. VENKATESH: Not done, so, it goes away. So, you keep waiting till you when you finish, you keep waiting. Now, the procedure.

PROF. MADHAVAN MUKUND: The procedure waits for the…

PROF. G. VENKATESH: Class teacher are waiting. Now the procedure finishes and is waiting, actually. I see crazy stuff. So, the procedure waits, and then the class teacher comes back because it is polling.

PROF. MADHAVAN MUKUND: Yeah.

PROF. G. VENKATESH: You asking, when it comes back and asked me at this time, I am ready.

PROF. MADHAVAN MUKUND: If I am ready and give it the answer.

PROF. G. VENKATESH: Give it the answer. This is a way to make it work. But there. But is it not possible? That I finished the procedure I finished the word, cannot, I just stopped the class teacher, hey, class teacher, I finished. Here is my result take.

PROF. MADHAVAN MUKUND: Yeah, you could do that. Now. So, you could tell that person called me back when you are done. But of course, the problem is that when that person calls you back, you may be doing something else. You may,

PROF. G. VENKATESH: I want to not like that. I want to basically to call the class teacher and stop the class teacher, from doing whatever. Class teacher was teaching? Let us say,

PROF. MADHAVAN MUKUND: Yeah.

PROF. G. VENKATESH: I want to stop the class teacher and give my result to him. Inside the classroom.

PROF. MADHAVAN MUKUND: Which is obviously not something the class teacher may want, depending on.

PROF. G. VENKATESH: May not like it.

PROF. MADHAVAN MUKUND: Yeah.

PROF. G. VENKATESH: It is very disturbing to the class teacher. But let us say for a moment, I would do that, cannot I do that?

PROF. MADHAVAN MUKUND: you could do that. But then the class teacher will have to, have a way of stopping whatever they are doing. It could be in the middle of doing something important. Collecting this answer,…

PROF. G. VENKATESH: Keeping the answer aside,…

PROF. MADHAVAN MUKUND: Keeping it aside in the appropriate place, like an X or Y or whatever. And then resuming whatever you are doing. So, there has to be a way off for the class teacher who is done this calling, to be able to interrupt their work and resume the work without losing the thread of what is happening.

PROF. G. VENKATESH: So, in hardware. We have this interrupted and all that, this same thing.

PROF. MADHAVAN MUKUND: Yes, same thing. So, there is a normal thing going on. And suddenly you poke it and say, No, no, stop,..

PROF. G. VENKATESH: Stop.

PROF. MADHAVAN MUKUND: Stop what you are doing and this is important.

PROF. G. VENKATESH: So, this is interrupted. So, I can interrupt the person and…

PROF. MADHAVAN MUKUND: Yeah.

PROF. G. VENKATESH: Is there a name for this, I mean in concurrency in our computation, computer science language.

PROF. MADHAVAN MUKUND: Well, sometimes you call it preemption.

PROF. G. VENKATESH: Preempt

PROF. MADHAVAN MUKUND: Preempt that is you, you kind of override what they are doing, and make them do something else.

PROF. G. VENKATESH: So, it is preempting them.

PROF. MADHAVAN MUKUND: Yeah, pre-empting.

PROF. G. VENKATESH: Preemptive. So, we have concurrency and we have this polling, polling is one method of getting the result. The other way of getting the result is by interrupt just by pre-empting

PROF. MADHAVAN MUKUND: Yeah, preempting.

PROF. G. VENKATESH: So, the guy when he finishes he stopped me, give me the result I collect the result. Keep it aside continue. Or if he does not allow to stop, which means I have not allowing this.

PROF. MADHAVAN MUKUND: Yeah.

PROF. G. VENKATESH: Preemption. If you do not allow me preemption, then the only other method I have is to poll.

PROF. MADHAVAN MUKUND: To poll, yeah. So, he could maybe poll me.

PROF. G. VENKATESH: He could poll me also. Either way, I poll him, he polls me.

PROF. MADHAVAN MUKUND: So, he tries to preempt me again, little late.

PROF. G. VENKATESH: He could poll me, I could poll him or he could stop me, give me the result, this is two ways. So, there is seen also this thing called threads and all that, multiple threads of execution is the same thing or?

PROF. MADHAVAN MUKUND: Similar, similar, yes, similar. So, when you start something, yeah, so you start doing something, and while it is going and start something else, and then, depending on the situation, you might be waiting for them to finish, or you might be just waiting for them to call you back when they are done.

PROF. G. VENKATESH: So, you have 3 or 4 or 5 things which are executing simultaneous, like 3, 4 threads, something like that.

PROF. MADHAVAN MUKUND: So, for the care of the class teacher normally would be in that situation, if you look at it from that thing. So, the class teacher starts off these three. So, it starts off the physics. So, the class teacher is here. So, it starts off some activity

PROF. G. VENKATESH: Start some activity.

PROF. MADHAVAN MUKUND: With the physics, maths, and the chemistry teacher.

PROF. G. VENKATESH: Does not wait for the teacher, it just started.

PROF. MADHAVAN MUKUND: it just starts it. But now the class teacher kind of,

PROF. G. VENKATESH: Now, you have 4.

PROF. MADHAVAN MUKUND: Kind of runs here.

PROF. G. VENKATESH: There are four things going on. Currently, now,…

PROF. MADHAVAN MUKUND: but the class teacher after I have started the class teacher, he may not have anything to do may or may not.

PROF. G. VENKATESH: Okay.

PROF. MADHAVAN MUKUND: So, then you are basically waiting for all of these guys to finish.

PROF. G. VENKATESH: And at least after the class teacher started physics, they have something to do, they have to create method,..

PROF. MADHAVAN MUKUND: Correct, yeah. So maybe a better way to think about this is the class teacher going down. And then it sets off this physics guy on this site, and then it goes a little further, and then it sets off the Maths guy on the side.

PROF. G. VENKATESH: Okay.

PROF. MADHAVAN MUKUND: And then it goes a little further, and sets off the chemistry guy. So, the class teacher is done three things. And in the process started three new activities, which are going on in parallel, and then at some as it is going, and then maybe it is doing something else.

PROF. G. VENKATESH: Maybe 3 threads.

PROF. MADHAVAN MUKUND: Well, maybe you are calculating the attendance for the month something.

PROF. G. VENKATESH: Something, it is kind of,.

PROF. MADHAVAN MUKUND: And then suddenly, this, this guy will come and pre-empt.

PROF. G. VENKATESH: pre-empt.

PROF. MADHAVAN MUKUND: Saying that, I have got the answer,.

PROF. G. VENKATESH: Or you will poll it.

PROF. MADHAVAN MUKUND: Or you will if you run out of things to do or if you decide you need the answer, you might pull. So, either way. Similarly, at some point, this chemistry thing will also, and it may not mean the same sequence you started maths first, but you might poll it third, you have some sort of order in which you decide to go back and get the answers. But eventually, these guys will finish hopefully, and the class teacher will now have the information that they need to give you remember this whole thing started because we asked for the best,

PROF. G. VENKATESH: Best friend.

PROF. MADHAVAN MUKUND: so the class teacher.

PROF. G. VENKATESH: Class teacher turn back to us.

PROF. MADHAVAN MUKUND: To finally.

PROF. G. VENKATESH: Well, we are also concurrently have done that. We have asked the class teacher to do something, we are doing something else.

PROF. MADHAVAN MUKUND: Exactly. So, the same preemption polling happens we might ask a class teacher. Have you finished? I mean, have you got the answer or not.

PROF. G. VENKATESH: You may poll or the class teacher, when it finishes, may preempt.

PROF. MADHAVAN MUKUND: So, you might tell the class teacher I have to print a certificate. Now you have to give me the name by tomorrow. So quickly, and meanwhile, we might be doing our own thing. So, ...