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So we now begin module two of lecture four so this is the last class of scheduling algorithms we will study in the resource contention building approaches and this will be heuristic fast solution approach so most of the heuristic fast solution approaches are based on the list based dueling strategies now this is a huge is tic strategy as we said and hence the solutions are bound to be suboptimal in, in most cases however as we said that because the optimal solution is highly time-consuming to obtain many a times.

We have to resort to such heuristic list based solution strategies and therefore the list based scheduling is one of the most popular scheduling methods that we have and we can consider this list based dueling strategy as a generalization of the ASAP scheduling strategy since it produces the same result as the ASAP scheduling strategy in,

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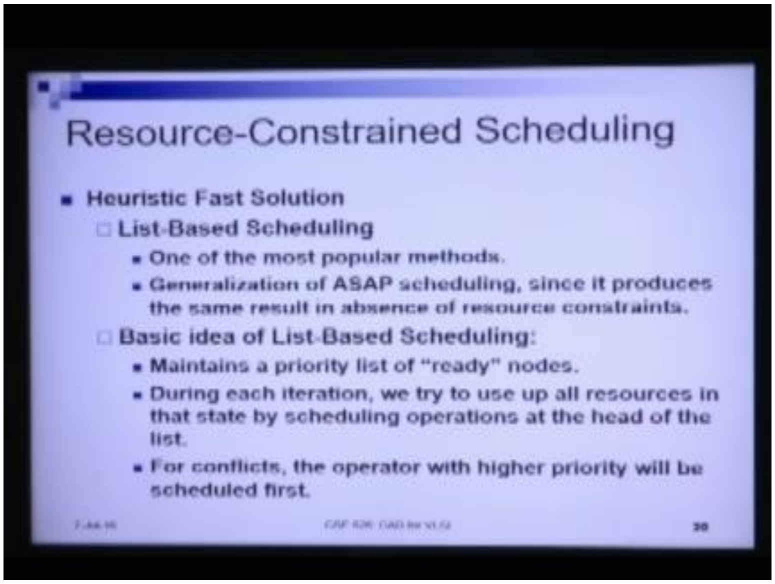

In the absence of resource constraints however if you do have resource constraints it will not be the same obviously so what is the basic idea on which the list based she would ruling works it maintains a priority list of ready notes during each iteration we try to use up all resources in that state by scheduling operations at the head of the list for conflicts we the operator with higher priority will be scheduled first so we have a priority list of ready notes that means firstly we need to obtain a priority among the ready nodes which is more important than the other.

We have to obtain relative importance values among the operations now we will schedule the highest priority operations at each time step to what to the available resources that I have at that time step all the resources may not be available at that time step whatever resources are available and if I have a ready to schedule set of independent nodes the most important nodes will be given to the available resources so this is how we proceed and finally scheduled all resources is the basic strategy.

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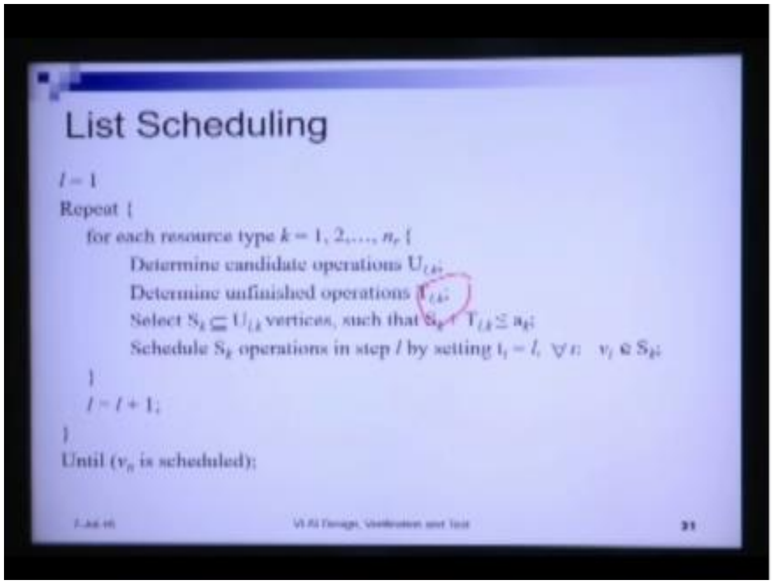

So now we will come to the algorithm so how does this scheduling proceed it proceeds time step by time step so L denotes the time step and we proceed with time step 1 let us say that I have k types of resources 1 2dot dot up to NR, NR types of resources k equals to 1 2 dot, dot up to n are now what is the first thing to do at each time step at each time step for each type of resource the first thing to do is to obtain candidate operations and then also determine unfinished operations at time step n so what does ULK determine what does ULK tell me UL get here.

ULK gives me the number of ready to schedule operations of type k at time step l similarly what does TLK tell me TLK tells me the number of unfinished operations at time step l of type k y will how why is this TLK coming here TLK is coming here because this generalized scheduling strategy assumes that resources can have more than one unit delay the delay can be higher than one therefore at a given time step there could be a few operations that are unfinished.

Hence the what is the next step the next step is to select SK a subset of you LK so I can schedule at most ULK of the operation because ULK operations are only ready now I cannot redo log because I have resource constraints and therefore I will select a subset Sk of these ULT operations such that SK plus TLk is less than equals to AK so AK is what the number of resources that I have of type k TLK is the number of unfinished operations now therefore how many resources are in total available at this time AK minus TLK now I can choose less than equals to AK minus TLK resources to share you the radio to schedule operations at time step in that is escape.

So she edge SK operations in time step l by setting TI equals to L for follower operation I such that VI belongs to s k & s K is less than a know has Sk been obtained through apriority function that we will look at there could be various priority functions and, and based on the types of priority functions the complexity and the types of list scheduling of algorithm is very however whatever it is you currently what we are considering that considering is that we have chosen a set SK of unfinished operations from ULK.

And we have to therefore assign time steps to these operations and that is done by TI equals to l and where I belong I for all I where VI belongs to Sk now if these operations have been allocated at time step l then we need to increment time we increment time and do again the same thing and continue until all operations have been scheduled so we increment time and again for each resource type find out the number of ready to schedule operations that, that have.

Now become available because I have incremented time some of the operations that that has already been allocated to, to already been allocated for scheduling have completed and then we can have a new set of operations in ULK and therefore of scheduling will continue in this fashion and we will continue until all operations have been scheduled.

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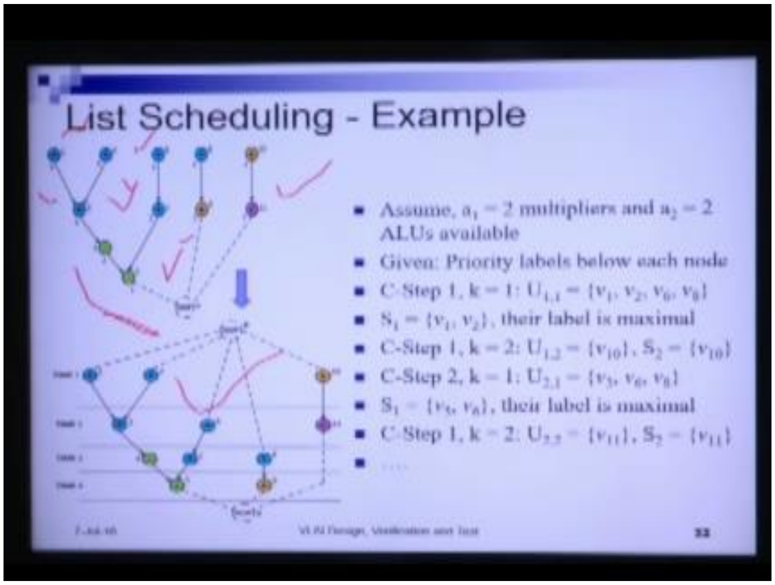

Now we will take an example in this example the, the figure on the top this figure gives me the a set of priority values on each node the index number of the node is given on the top left corner of each node so this, this one here this to hear these are the index number of the operation ids of the corresponding to the operations the values on the on the left bottom corner this for this for tells me the priority values corresponding to these operations before the leash scheduling arm algorithm as we said that we will have a labeling of priority values attached to each node this is one arbitrary labeling that has been attached to this set of nodes

Now how has this been obtained the this priority value has been obtained as follows this gives me the, the weight of the path starting from the current node to the sink node so for example let us consider operation 5 this the weight of this path is one because the distance there is only one node that is only one edge that takes it from this node to the sink node again the weight of load for is to because the length of the path from the node 4 to the sink node is to the, the weight of, of 3 and because each of these nodes have unit delay.

So the, the length of the path also gives me the weight of the path and that also gives me the priority and hence the label or the priority of let us say operation three is what is three because that is the distance from node 3 to the sink node 4 nodes 1 and 2 similarly the priority value is 4 for node 6 the probability value is 3 because see the, the length of the path from lone 6 to the sink node is 3 the, the priority value of lone seven is too because the length of the path from node 7 to the sink node is to this is how we have obtained a priority labeling of all nodes in the operation constraints graph.

Now here we again assume that let us say we have two multipliers a1 equals to two multipliers and a2 equals to 2 L use that are available to me now given this priority levels we will operate these will progress time step by time step list scheduling progress is time step by time step and at each time step the first thing we will operate for each operation type so let us say we first look for multiplication k equals to 1 is multiplication so how many multiplication operations do I have I have v1 v2 v6 and v8.

Now I can allocate at most two because I have two multipliers now what are selected v1 andv2 are selected why because v1 and v2have the maximal label so the value of the table is value for both one and twov1 and v2 is for that for v6 and v8 the other two available nodes at time step one of multiplication type are three and two and hence v1 and v2 have higher priority with respect to v6 and v8 and therefore we at time step 1 v1 and v2 are selected similarly for the second resource type ALU what do we have we only have v10that is available.

And hence the operation v10 will be allocated to 1luresource at time step 2 similarly what will happen I have v3 v6 v8 so v1 and v2has already been scheduled now becausev1 and v2 has been scheduled v3 becomes available because its precedence constraints are now satisfied and therefore among v3 v6 v8 we take v3 andv6 why because v3 has a label of 3 andv6 have also has also a label of three while v8 has a label of 2 so the higher priority nodes are v3 and v6 with respect to v8 and hence they are scheduled for the new operation what do we have we have only v11 that is available v10 has been scheduled v11 is the only operation that is available currently.

That is ready to be scheduled and hence it is allocated to it is allocated to the adder resource and scheduling proceeds likewise and the final schedule has been shown here with this we come to the end of module 2 of lecture 4you.

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