**Indian Institute of Technology**

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**NP – TEL**

**National Programme**

**On Technology Enhanced Learning**

**Course Title**

**Compiler Design**

**Lecture – 12**

**By**

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Sorry and the error in passer do the corresponding equations and we had a choice,

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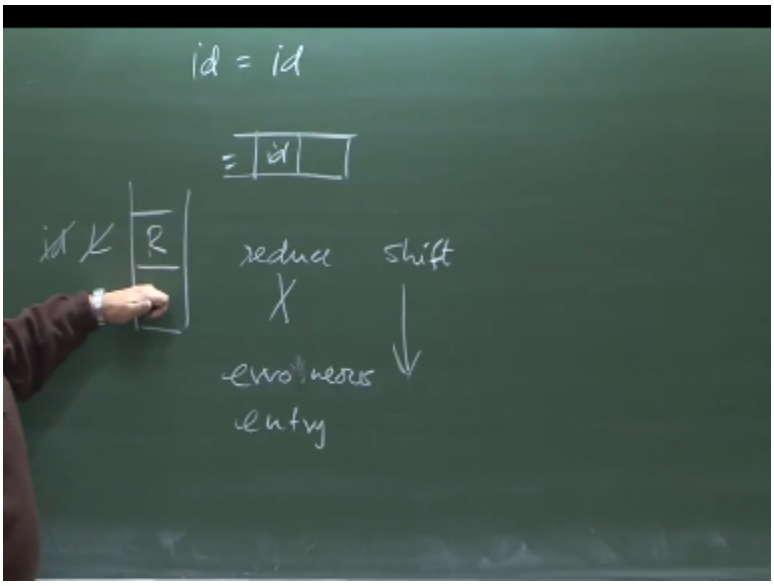


Between reduce and shift and we found this path does not allow us to process but it will take this part then we able to promise. Now obviously that which means that is when I got this conflict shift reduce conflict if suppose my past able did not have this new section then I already find that means this entry somehow it is a erroneous entry.

Entry should be removing then we said why we are saying this is erroneous and she because we are saying that there is no central form in this language which can start without. If I now spend a sentential form of this grammar then you find that it is giving me a sentential form which is R. = Id and the central form .So what is wrong okay guys I come to situations where my path still has this entry ideally it should not have that so there is the power we understand then you find that subsequent.

Especial become very easy for everyone any ideas you say something think a lot let me hear me your saying that is something called has state symbols. So top of style always containers the hints. What is the state symbol? Want us what is the information captured by the states symbol in a bottom up parser. This will be discussing in this beginning. Can we start doing bottom of the parser?

What is the information capture by the state symbol so state symbol is capture with concentration of state okay. State symbol if capture contribution of struck then final. If in this cause state

symbol should have been such we should have remembered that there is no sensation form that can come with starting with R and therefore this production is wrong. So whatever my earlier state was it should not have come to this state okay. Now let me try to explain that in terms of your honor suppose my configuration is like this,

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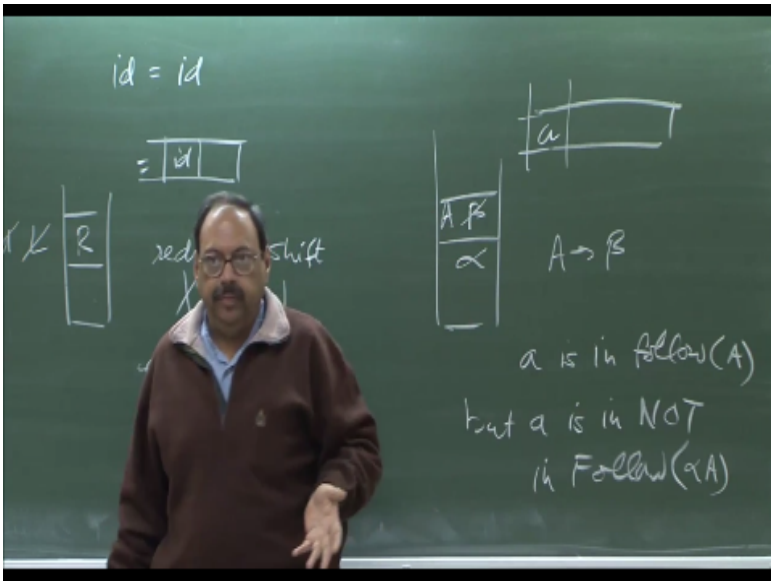


α and β, and some symbol production with A goes β. And then I have symbol here let say A sub term is okay. Now I will do the deduction, I am saying that is a production β is handling. So when will do the production okay. When this symbol look at symbol is in follow of e that we gave now suppose I do this reduction. Then have problem okay and exactly what is happening here that although this equal sign is follow of r but it not follow of when I is at the beginning of a string.

okay so if now look at the situation that a is in follow-up a but demo hands if I have a situation now where I say this symbol is in the follow of it but the symbol is not in follow of L Phi L Phi is my configuration after this reduction. Then I have a problem and exactly this is what is happening here that although this R is in this equal sign is in 404 but is not in form of when R is at the beginning of fasting.

So therefore if I can now remember the full context that means the stakes in villa hat is not popular stage symbol if I look at this so this is using this information we ate all sets of a lousy refuters and then create a pathway so first thing I want to do now is I want to change or introduce a new definition and rather than saying I have this set of L of new items let me say I have now set off hello - yes I am introducing now more information.

So that I can remember this whole of the left on this one item LR one item is nothing but and allows you item by LR 0 item and on you I promise similar production but here I am saying let me also associates with this symbol and this symbol is eventually is going to be used for reduction so typically what can happen is that if I have another veto item like this I am saying that let us see have some present and what is the significance of this symbol this symbol is basically saying that at some point of time .

When I keep on going go twos on this when I say that from this item I go to and I turn on good Y which is going to give me an L of U I turn off a go into X Y dot Z and then I further do or go to on that which gives me a going from X Y Z dot and when I'm ready for reductions I'd be able to reduce only on these symbols I remember now one thing that must immediately come to your mind is that of this look at example earlier.

I was mean a reduction on similarities for no reason so this symbol must still be following but not the subject so the way we are looking at it is that this symbol is in photo of our a but now I want this symbol to mean follow our beginning up okay or when I say that this symbol should be in form of a I want this simple also to be in form of L 5 so this set is always going to be subset of what is following so this look at my back I said all these items are going to be low and not taking this definition not saying that since.

I do not have these items anymore I have not allow the oil to be fine no you are wrong set of an item will be something like this so now I say that if I have in another night the form which is able to help out on indeed up and equal to $\gamma$ is a production then what is no I am very light in this I will say that I am going to add now B going to dot $\gamma$ and what we should look at symbols first off the partially pair of military.

Because what may happen is we tie his mother right so it will now be first complete array so this is now giving me extra information thank that when I do this I can do this reduction only when I have a simple vigilant first off be back in first off it is going to be a subset off form of me and this now capture look complete stack on division so my new state is so powerful that rather than just says if I do a reduction on.

This symbol this is saying I will do a reduction only if the symbolism follow-up whole of the stack but this such this is going to be is going to be a SLR parcel has a limitation and how we are putting more information in this parcel if I am reading the information in and now I can go to this new parsing method when I say is so powerful that not only if she remembers what is bellowing but it remembers what is on the stack my earlier stage was just able to remember.

What is below it okay but this new state will be able to remember what is on the whole of step because now it will know that not only I know that this symbol has to be in form of are calling follow of whatever was the reduction form of N and that is when this reduction happened but it should also be follow of where are others at the beginning and if configuration is not acceptable configuration then earlier reduction would not have taken use.

Yes so let us take again in example and try to construct now a new parser for this and this new parser I am going to call is Coronial LR parse and in fact this is the most powerful thing but what we are going to discuss canonical LR parser and that we also say with a look ahead of one. so if I just want to do a look ahead of box is the most powerful force another if a language cannot be passed by this then we are going to say method is powerful ml is the language.

Which is not in this case in case we said languages are ambiguous method was not powerful enough right we went for a new method in this case we have to say let us try to construct now let us try to construct now canonical LR parser,

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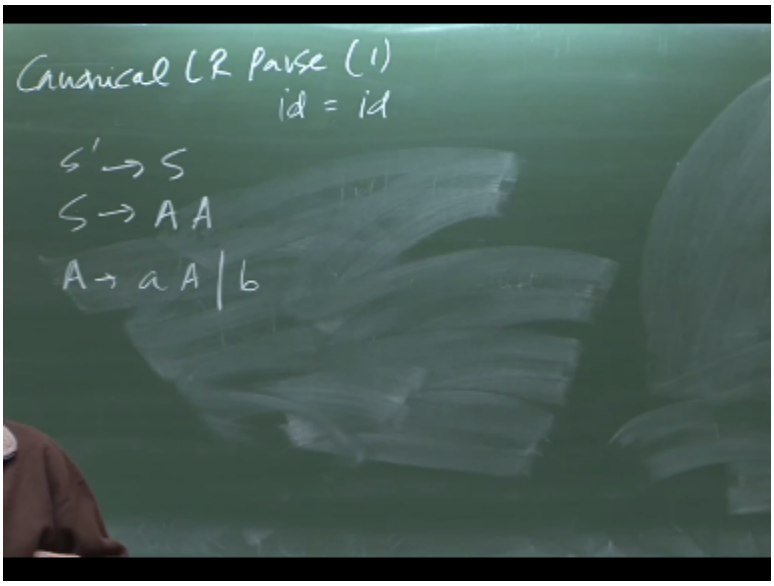


And which I am going to take so let us keep these definitions from the tiny swing this part of the board and let me pick up an account. So let us say I have this number and I will explain why we are taking this γ in this grammar has something very interesting let us take this down now this number says one of the languages which are generated by on one of the screens which are generated by this γ.

And if I say s supposed to be not a reason so look at the second rule a goes to a that is the right symbols were goes to B If I say S goes to A a there I can generate A struck B struck the reason of I am saying is A stuck and B stuck is I want in these kinds of languages that earlier method of parsing you would have found the follow set of this form a set of these are different now in earlier pattern what is the following set of this A $ and what is the follow set of this excited.

A or B right so in earlier method okay you would have noticed that this reduction would have been taking place on $ also. So if I had written a string like A * B he could have done this reduction and would have said any further okay so the reason I am repeating this symbol is that the follow set although this symbol is same but because of the context in which it is occurring in this case for a set of this age $ so this voltage attack can happen only based on and this first part of the a can be reduced.

Form whatever is then put only on A and B not and all on so that is going to separate on files. So let us start constructing now parse of this and again because this information look at information to be carried as part of the 11 items okay so computation the follow set is born so what happens now is that if I say I want to now construct of this.

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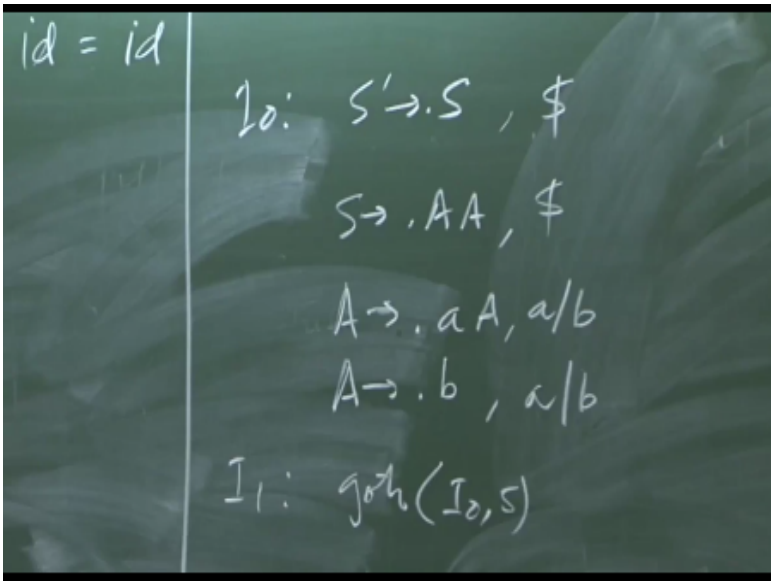


Now my look at symbol is going to be very simple for this position is X Y in do this reduction only knows and let me call this as is you and now when I say that I want to take a closure right this is my initialize so closure is going to give me s going to a right there are only one production of a and what will be the reflection okay this next time this definition here okay so if you just try to do a pattern match here and I am coming from this item to this item okay this is where I am taking closure.

So look at this that if I say I have a non-terminal symbol immediately on the right oh dot that I am looking at first of the time now what is λ in this case what is behind this case what is beat up no so I am looking at first off at silent $ that means me taller so my look ahead will be this now I have to take closure of this age right can I say a goes to a or a goes to not me right now what it is a look at it here.

So first let us write that state what would be the look ahead here how will I compute look ahead for this first off first off a $ now what is first off A $. So these are my look action okay what about this what is the symbol came here because this closure is again coming from that eventually somewhere I should do A transition from this state when I say go to a state where I will have a look ahead as be okay and that state is going to contain a going to be dot.

And now you can see that when I do the launch and I do only on these symbols and not and all β because now I will say I want to do a reduction of it but I want to do a reduction only when my carrot symbol is this so I will be able to reduce this deep way only of these new heads and I will be able to reduce this they do this reduction only or maybe an orphan god in some other state you will find that when I better circulate and that which is scary computation of first item clear.

So this is my initial state always and from this non computing extra information so next state I say is go to off I 0, S and let me call that as I want okay so first tell me what will it be so obviously do a transition on S so it will give me a start correction right first off how much so change in my definition go through. What I giving two definition of go through so you saying computation of pass per anything that was only for glow here.

My glow should has it is that means this symbol has to just carried. I do a shift here in whatever is look at just carried that. Do not know any computations remember that I only give a good definition could not equal definition in the board. The my go-to will still contain the same set of subsets of LR 0 item and whatever is the look ahead that gets going then next thing I do is so I cannot do anything more on this now. I say that I go to was state which will be corresponding go to off I 0, A knew on a let me call this state has,

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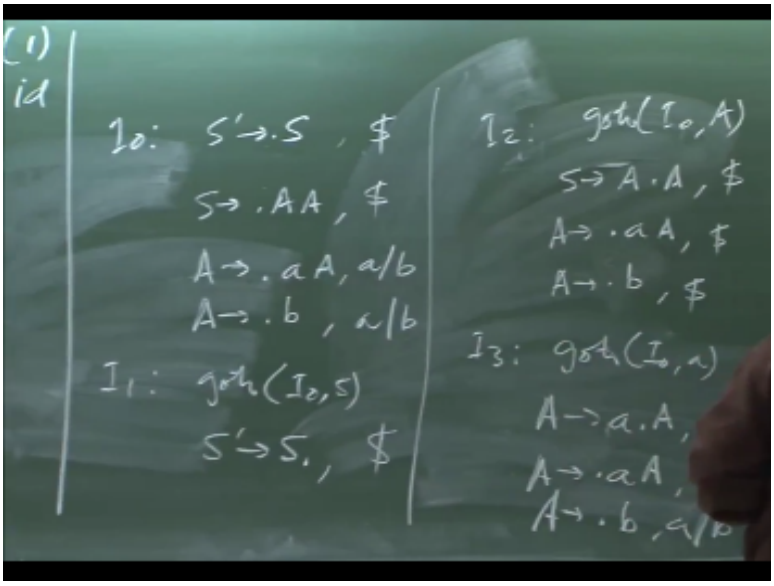


I 2 okay which is coming from here so this is me S - to A.A right I do not only all the item of the computation whatever is the look at it here I just came in it okay I could have any computation look at here I carry that total is going to give me a going to a and a 22 holy they can go love it exciting total very good because I am sitting closure because of this non-terminal .

Therefore my beta if you just match this pattern β is epsilon yet so I am taking first off absolute knowledge and therefore my looking at here taken $ here cost of the silent of very good because I am checking closer because of this non terminal therefore β if just back in back β silent here so I am taking $ is going to be $ now you can see a difference between this and this here when I was having this tape which said A goes to dot B my look ahead was A B and here when I am saying A goes dot B .

Okay and is $ that means when i do a reduction from V a in some cases I will do a reduction only on this look ahead and in some cases I will do A reduction only in this look at and in some causes doing reduction of in this look correct because now my parser is able to remember that whether this is the first part of A * B coming out of this or this is the second part of A * B coming out of this I have separated these mistakes.

In earlier cause is constructed and this L R parser then this was not being carried and whenever I had this situation which says A goes B dot I said follow of a contains A B or $ and I will reduce

here clear. So let us move forward and then we say I want to now compute go to off I 0 and already done it for A swing of the small okay.

And let me call this s by 3 okay and this is going to give me a going to A dot A which is coming out need of this okay and what will have looking ahead k op I do not have to compute anything I just copy this right now I take closure because of this so if I not take a closure which gives me a going to dot a and A going to dot B what will be look ahead symbols here a on b because now these closer items are coming because of this A so therefore I am taking first of f epsilon and then a or b so that it closer equal to 4 this ought to be little symbols here right because now these closure items are coming to a or b okay.

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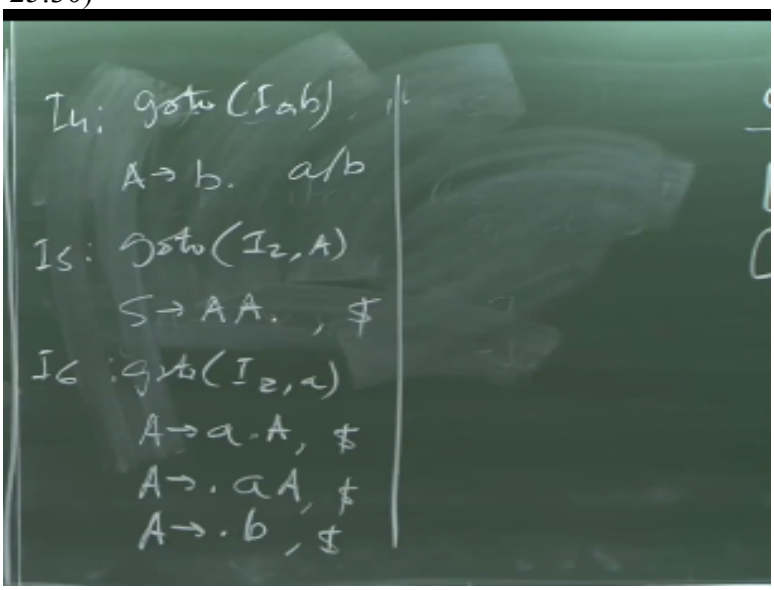


So let us move forward from this now I innovate this form and now say that means if go to one I will give a b so I am doing now go to on this and let me call this as the new space called forth and this gives me table two b dot and what is looking at here and that stopping at that computing it okay and I cannot try to go to this a little weird I stop all conditions of i0 okay now I come to I one I cannot do any transition on I one here.

Then I come to I 2 so first thing I notice is I can do a foundation on a so if I do a transition on a so let me call it as go to off I to a and this gives me s going to A okay and what we look at now dots it because I just need to carry it along and then computerizing let me called it as alpha and then I cannot add anything this and more to this then I do this on this side which says go to of I to on A right and this is E what does it give E A going to A dot K have I already computed something is not it same as like T look that is different.

So it is not saying it like very good you were able to catch that so this is now I will have A going to A dot A so I am coming from here right and this is giving me a look ahead of dollar let me call this as i6 okay and this is not same as this day because new sets are different okay.
And now I will take closure here so this closure is saying A goes to dot A and A going to dot B and what into the look ahead symbols here dollar again right so I am looking at now first off epsilon and all this gives me a dollars okay so i6 if I move now from i2 and I now do a condition on B okay.
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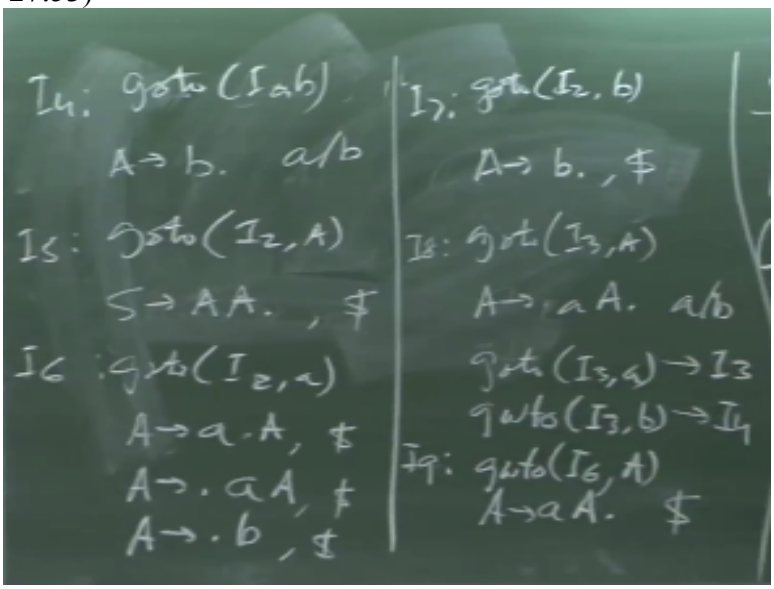


So this is going to of i2 of B and this which mean a goes to b dot and A is goes to B dot although I have I post it but because my look ahead is different therefore I will call it as a new step and I call them as state number 7 okay and this is not add anything more to it and so I have exhausted everything in right I2 okay now I come to I 3 and I can do a transition on a ok.
So if I do now go to of I3 or A what does that give me a going to a A dot and what does it look ahead here look ahead will be same as this if it is A and B okay now look at the state does not exist anywhere so let me call the state as IE and if I now look at this particular state which is able to go to of I2 on A what does that you mean gives me a going to a dot no kind of AD and that is I think that is not a new state so decide that will back to I okay if I now door condition on B in this state okay.
So if I say go to of I3b go to of that gives me a going to be dot with a loop ahead of a B and that is I4 okay if I look at I4 and I cannot do any condition if we look at I5 no more condition s possible if I look at I6 I can do a condition on A okay so now I can compute go to of I6 on uppercase a that gives me a going to a dot and what does it look at forward I just carried forward

and this is this does not exist anywhere So let me call this state as I9 okay if I take closure does not type anything of this okay.
And now if I so I am here if I do now a transition on this if I say now let me keep this definition intact and if I now say go to off I six on A yes that is means I6 itself and if I do a transition on B if I say go to I 6 B what is that a going to b dot on dollars is I7 say so I have exhausted I6 I cannot do any function on I7 and cannot function of condition A and cannot do condition on I9 lambda okay this is always we construct on i9 and complete.
So now I can construct my fast table now and the rules in the same okay so what are the rules now that I can have only an except state the except state is going to come from this okay basically whenever you do this reduction and my affection will is dollar and then I will accept okay.
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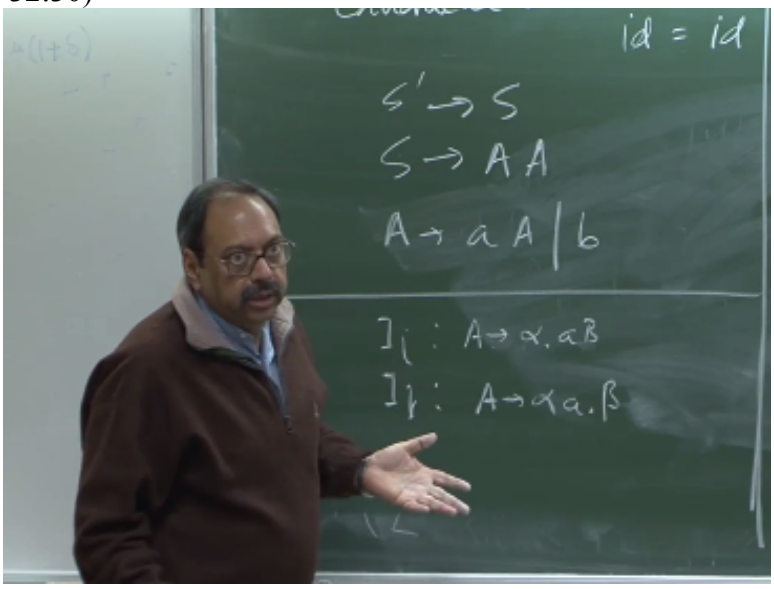


But if I look at action part and go to part they are going to remain the same at least the shift part in action is the same at earlier one and the state 5i and this state is containing and allow zero item of this forms let us say I have alpha dot is B and then if my new states J the corresponds to equal to alpha a dot b up I have done a transition on this so what is it that I look and say if I am in this state then on a I m going to say shift to G that is the only thing I did and what we happen in a go to part happen for a non terminal in the go to part okay so only you think that will happen is reduction not okay.
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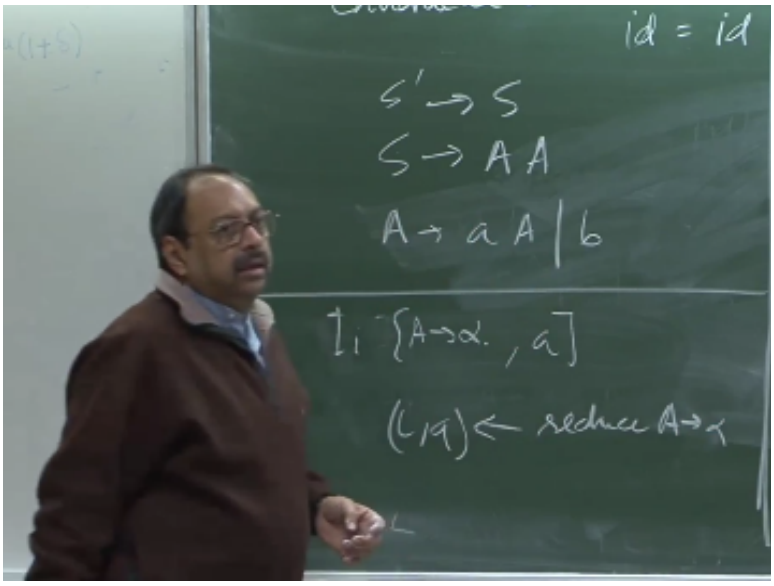


The earlier rule for reduction was I was saying in case of a new section he said that if I have this particular and R 0 I drop in some state so suppose my state contains this then I was saying in this particular state if you find that the symbol which is the fallow of A then use this by this rule then now will change that and now we say if and this state okay if and I have symbol if A then I of A is going to be reduce by regular form instead of saying if the symbol is in fallow okay.

And I carrying this information as part f my L1 term therefore that will be a reduction is on separately what was a limitation of epsilon parser how we move that limitation by carrying a extra item and a one item and then truly conduction and how my compute all my set of a items is this clear both of I will get from as well as the concept anyone have doubt on this you don't ask any questions or I will ask questions you can request immediately.

you give a grammar as the set of grammar items right away you if you do not ask questions want to do that so I will do be a check right so it is non terminal steps okay without worrying about I just keeping any grammar and I can do without saying you have a non terminal productions of this right so I can do the states were the change only one production from non terminal and I simply saying I am talking with this conditions to the format.

So that is will be okay we want to same grammar which you had a previous class with respect and the non terminal one part of that right away and any question no not in the quiz an assignment you want this I get it I ask you to do a simple assignment which you did not do you should not bother you can tell me okay it is an assignment to be submitted okay and submitted tomorrow you have a grammar with you okay so let us then move forward and I what I do now is I will sort out right to capture this into giving materials what we do so this is have we discussing that if I had a shift action.

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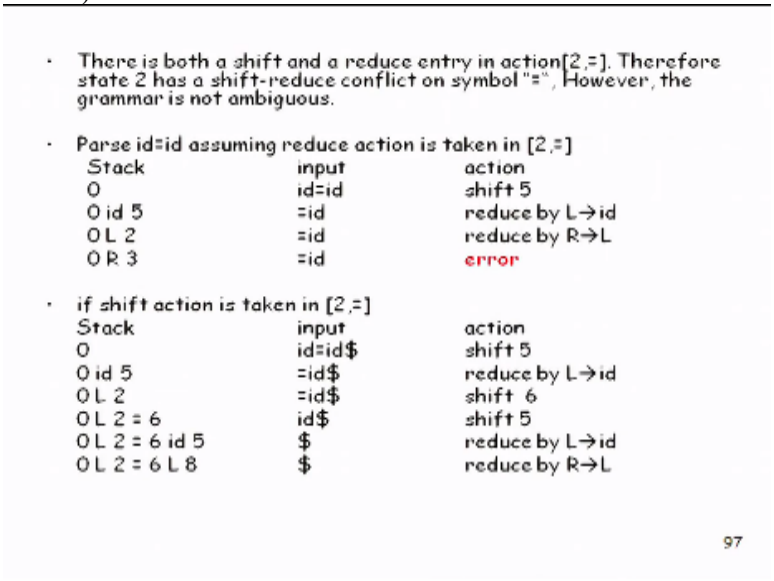


I had a new section and I had the shift action I had a new section that was taking it to state and if this and if I did a shift that was taking me to the correct state and the limitation we saw us that this state symbol was not able to remember the whole of left context.

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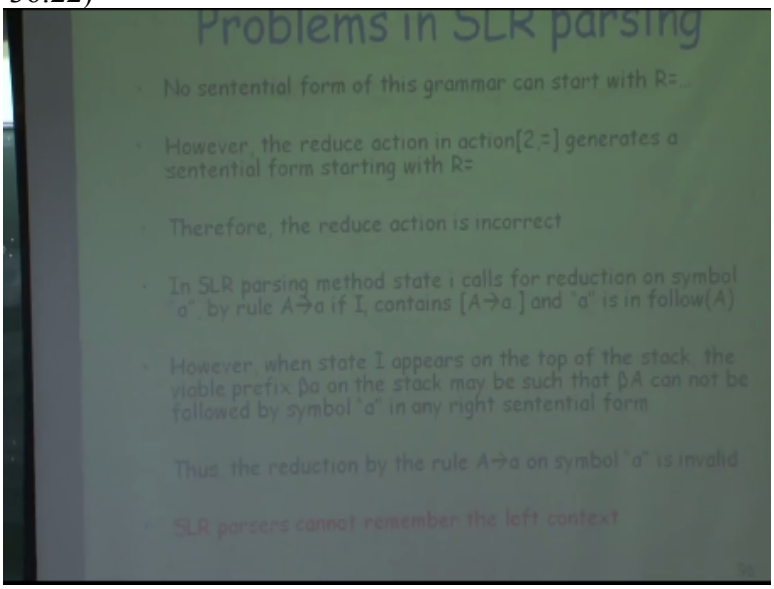


And therefore what we did was that there is no non terminal form which can start with R equal where R is in the beginning and the new section was deleting.

The penitential form of this form and therefore the new section is incorrect and in SLR parser when I say that I am doing reduction by this symbol this symbol may be in follow of it but we are not being followed of and Phi and therefore we said this symbol is invalid and problem is that the symbol same symbol does not capture the lat context there is no actual full state configuration just captures the signal on the top and that was the limitation.

We wanted to remove and because of which we said in canonical LR parser we are going to carry extra information that whenever reduction by this rule happens we will try to rule out all the wrong reductions and wrong deductions are happening because of a simple to follow of it so I am carrying extra information which I call as look ahead simple and I am going to do reductions so if I am in some state if I have some elaboration.
Which is of the form a goes to alpha dot beta then I need any extra information like a which I am going to call as a LR1 ID and reduction so this items a LR1 item and the look ahead symbol in LR1 item is only going to affect my reductions and nothing else so how I am saying that if I have some item like this it says it goes well for today then I call for reduction only if next input is a okay so this is now making sure that next input a although is in follow of it but I am NOT looking at all symbols which are in follows way but I am looking at something which is in form of the whole state and so that is what I captured here okay so it is a symbol which is in subset of follow here.
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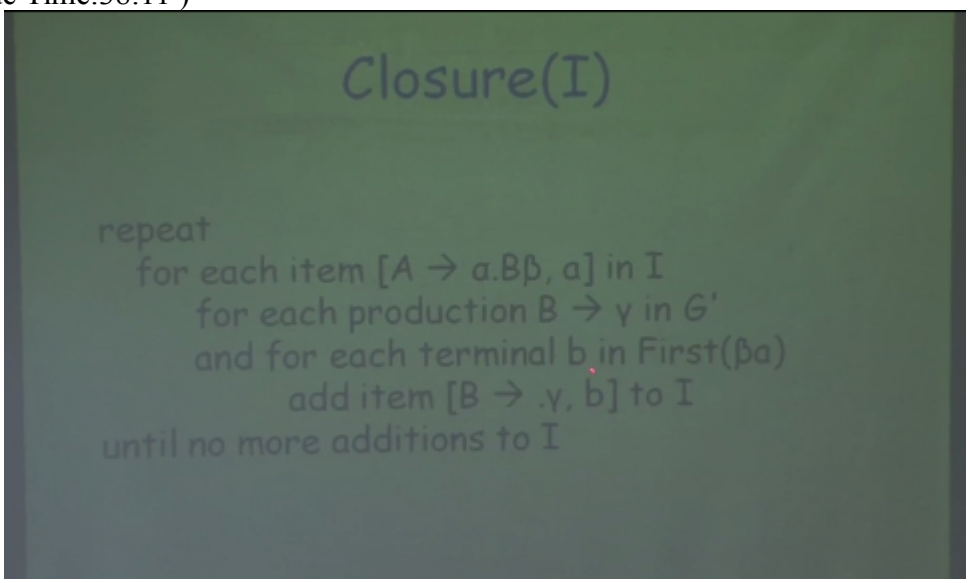


And the closer I is the only definition I changed so I said if I have this particular allow one item which says a goes to alpha dot B beta and we going to gamma is a production then I am going to add another LR1 item to the closure which says B going to dot gamma with the look ahead of B where B is in the first off we done I do not change anything in go to.
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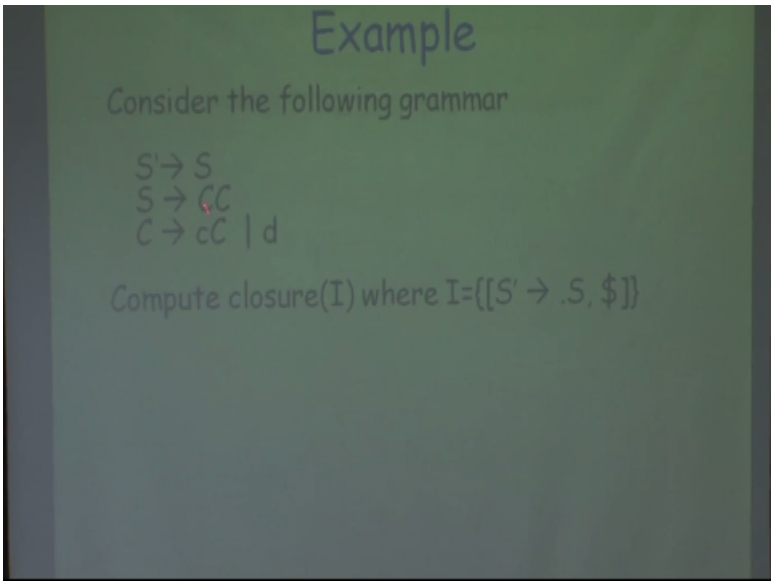


So we looked at so I am slightly different grammar but basically same similar rotation where I have a repeat and okay.

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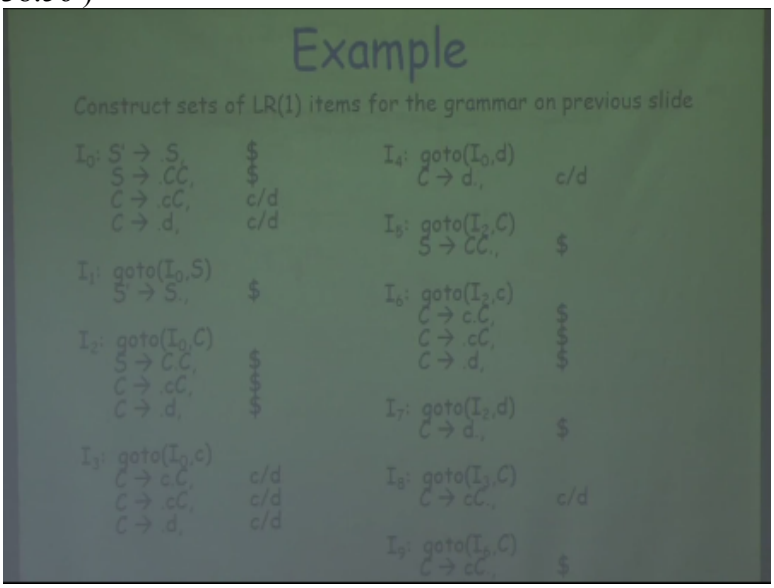


And then we constructed all sets of LR1 items for this and this is how we ended up and if I now construct the in all things okay.

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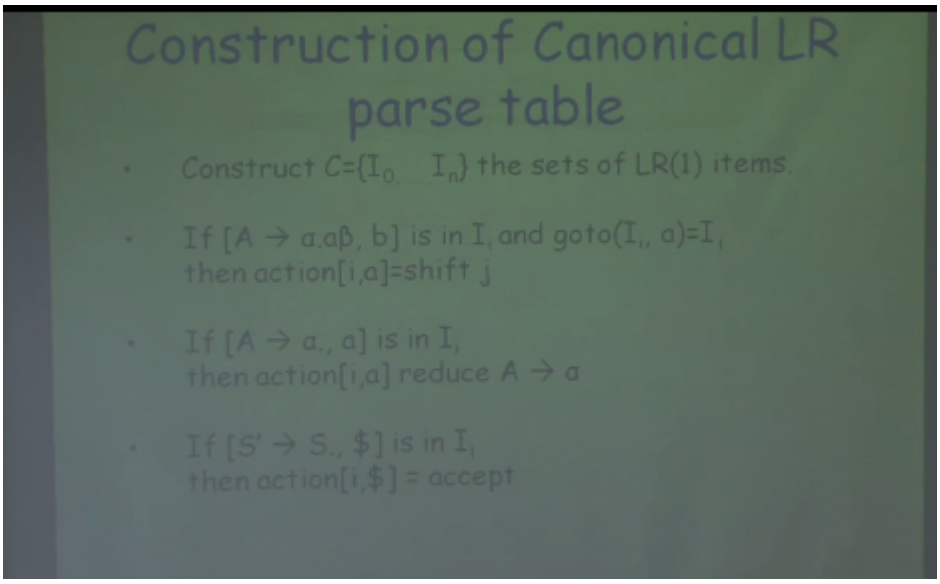


And I construct the pass table all my rules remain the same except this rule where we said that I am going to call for reduction when my look example here is A my shift rule in go to rule we lost it okay they are same as epsilon parts.

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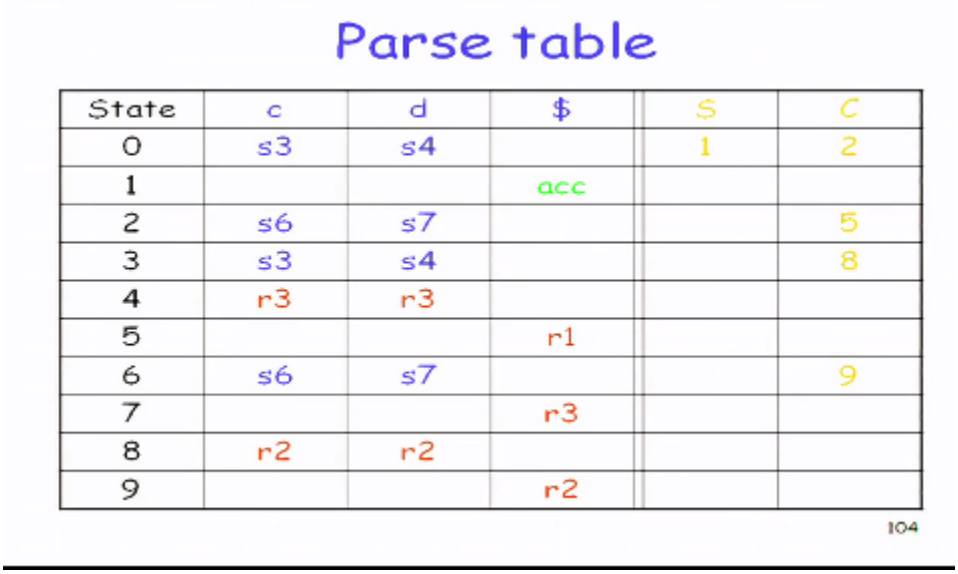


| State | c | d | $ | S | C |
|---|---|---|---|---|---|
| 0 | s3 | s4 | | 1 | 2 |
| 1 | | | acc | | |
| 2 | s6 | s7 | | | 5 |
| 3 | s3 | s4 | | | 8 |
| 4 | r3 | r3 | | | |
| 5 | | | r1 | | |
| 6 | s6 | s7 | | | 9 |
| 7 | | | r3 | | |
| 8 | r2 | r2 | | | |
| 9 | | | r2 | | |

And this is the kind of cross table I will give okay so now let us look at something interesting actually that interesting thing is that if I am in this state yes I am doing a rule by reduction by rule number and this is my rule number three okay which says that B goes to a okay but if you see here if I am in this state then I am doing a reduction by rule number three when my to correct symbol is okay so it's not that every time I will be able to reduce by this rule which says it A goes to B I have separated out these states in epsilon parts will would have notice that this NP would

have contained of sets R1 dollar to the reduction and these all are symbol because dollar of this in fallow it but here .
I was able to separate out X Y here I am using a different symbol C so here I am going to separate out whether it is a first C and the follow of the first C is only C or D so the follow of second C in the form of that means it contains only the cover so I am only doing reductions in this case on CD and in this case on dollar and in this case. I am doing reductions number two and my rule number 2 is this one so depending upon whether it is the first part of the second part.
I am doing reductions on two different sails this is what we have discuss now so let us look at some of the properties okay.
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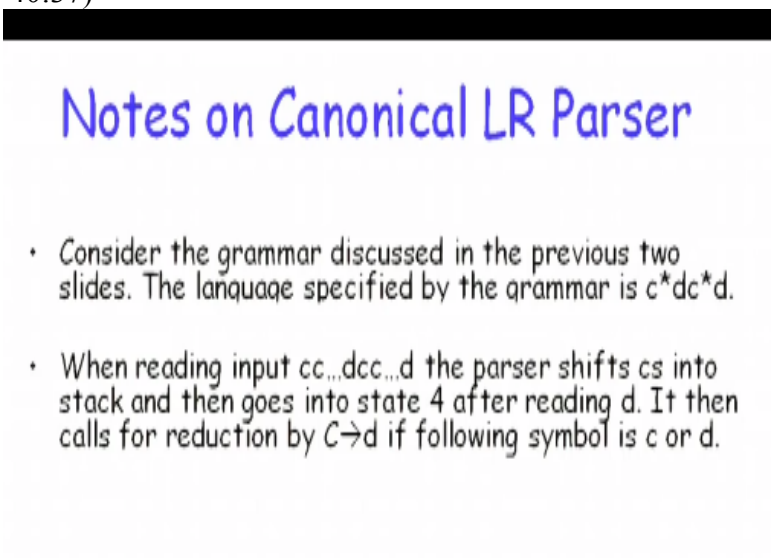


So this language which is specified by the γ okay so in this case I am using slightly different same route selection this was lower case and the upper case in the first C we can create problem I changes example ,so this is the string which is specified by the language and when reading I am reading this input which is CCD, CCD and so on Jo since tardy parser is going to shift all the C's into stack and then goes into state 4 after reading the D okay and only here you will see that I will able to this reduction only if it is follow by COD that goes up two difference cases and if dollar is followed in the first than we say that is input is correct or incorrect parser goes into error.
So earlier case you have just the reduction okay an error conical parser this is a very interesting property and makes it so simple most powerful matter is that wherever there is a input okay if you just refuse it will not committed in any shift or any use it just catch therefore as per as reporting and recomprisement this is a most powerful part not permanent any ground okay only

problem is that only can answer okay now Deeping closer number so suppose I had language like C okay.

How many state parser will have some wildness does not matter typically you find that we have around 700 states in a C parcel okay suppose a canonical parcel the number of states maybe there is an order of magnitude of difference so increase by 5% 10% there is a order of time difference because in the worst case what can happen is I am looking at worst case scenario if I look at all the set of each of the symbols for each of the symbols, I can have a new entry so if I have n symbols in the follow set all these n symbols can give rise to one line right now that makes it something which is which is very large also.

Computation is going to be computation of this particular parser that means creation of the particle itself is going to be possible it is harder to see it I have to consume so many states so what do we because we have got this very tough of correctness we are also worried about efficiency to have such large positive so maybe by saying that I will do all these things in I am going for an overkill if this is all of the part can you think of something better something.

Which is a compromise between SLR which is the weak as possible we can spark similar to found what is LALR which is most often and part of that evening will that take me as a lot so folder list that suppose we make all the space and merge them and on the simple switch they reduce let me give a slightly more clear and technical notation to what we are saying defined see all my LALR item so let me go back to the set of elevators items okay so look at some.

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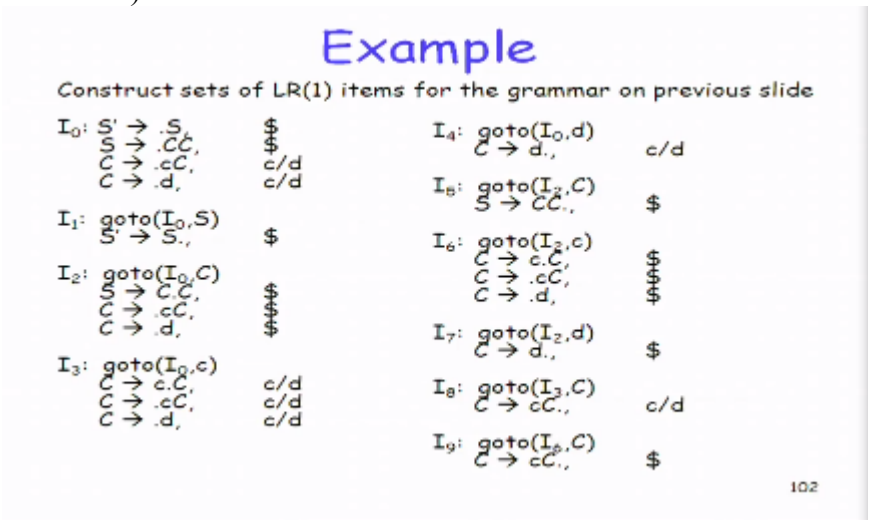


So look at some one LR 1 Item look at four okay four has saying C going to dot D look at the head of CD and seven has c going on D dot and all now when I say this is an LR 1 item I say this is my cornel of LR 1 item which is basically LR 0 item and let us look again similarly if I look at

say 6 and 3 the cornel is the same look ID is different if I look at 4 and 7 cornel is the same ID is different if I look at 8 and 9 cornel is same and the look ID is different.
Can you take all this phrase which has the same cornel and different two character and merge them is that what we are saying now what happens if I merge you will get we get closer to SLR new will not get SLR if I get closer to SLR is that more powerful than SLR but obviously less powerful than conical LLR perhaps you do not know okay today is one proposal okay since like a good well done proposal because all I am trying to do I reduce the number of six the same is rather than having a tens place 0 to 9.
Can I reduce number of states so how many people want to merge this state and what are the interagency more important thing what are integration so first question if I merge all these sets how may be my parts will be is it going to be smaller than conical LLR larger than SLR in somewhere in between or it will be something of some other size so if I say SLR some number of NPs and conical LR has Some numbers of NP and what is being proposed is do some merge.
So let me call this merger partner for time being number of states okay will it be 10 % lower than this 20% lower than this 10% higher than this 20% higher than whatever the estimate all in the some way middle average what is it c is the number of the SLR how do you say that that is an excellent option of the version okay let the number of states I get after doing this merge and because the condense are same.
That means now I am merging all the states the same contents in the two connects okay and therefore number of states I will say the same as SLR I think that has very powerful matter now because now I am saying that I can pay the conical boxes I want to reduce the number of sales and I reduce to SLR issue remains by merging is it possible to reach SLR pass table because if I say sizes SLR power is also SLR then what I have to give nothing.
Power is off what is he now conical error well power will not reduce okay so power will be same as conical LLR so what we do is we will break here today and tomorrow we will close this session and we close this parsing and we go the tight checking only few things are left okay and we see what are the inflections of doing this merger something which is in between of get back to SLR and say I did not mean anything so let us break here today tomorrow we can continue our discussion.

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