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Compiler Design
Lecture – 23

by…
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So after finishing the syntax directed translation of expression we want to take all the control for and I get into contacts. So we generate the technical your going to same which is a translation of to do now is that has I taxis take a rule which is grammar rule of this form I sum one 1 2 generate code form is strait. So first syntax and how you are going to code for this and I will introduce now few more attributes for this and again I am going to use of script which will try rotated between E1 and E2 and so that these are same symbols but we have different problems.
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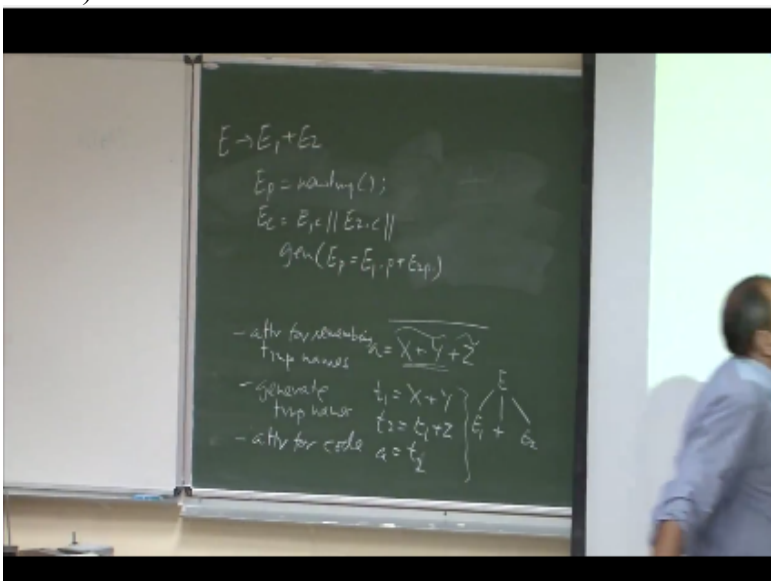

So one thing I would to like to know now is that if you recall when you generate to this code then I am going to something like this and suppose I say A is sign X+Y+Z you want to write deport for this T1 = X+Y and E2 = E1+Z and then A =T1. So as I am going through this process of sparkling and simultaneously I want to get this one the one that if you look at these variables T 1 and T 2 that means I must have some functions which can generate income this is funny you happy rhythm second things act when I passed this particular spin his X+Y.

I am going to put it in a convey the name and then I am going to parse this and this together then I am pass is going to put the values remember where each of these expressions is need and store. Therefore I must also have some attribute for then I would not be able to get it in the next eight I have to do this that I must remember water because this is a so I must so let us with all these this example let us see that if I just have grammar cool like this and I am reducing by the right hand side then I am reducing E and T so one is a poor sequence for this of it.
So let us look at this for secrecy now as I said so first thing I must remember is that which is saying in there right next thing I am want to do is once I show these places I left we generate a temporary name corresponding to this and say that these two variables are added and scored is that particular location so the way I can write my code is I can say that each place is a new pen so suppose I made a function call without any which says that each place is going to be stored into the temporary name I have get it and then I will say that what is the code corresponding key trying to complete four signals corresponding to this particular T.
So look at a party like this that I have some nodes which are hanging like this is how my positive will to be so now if I say what is the code corresponding to e and so if I say it is even port very good unethical with so I must get rid now one instruction to say that through this addition okay so that means the next instruction is going to be that I am going to now the rate which will say that each place is even place plus so first thing I said was I am going to give it a fitting name and then I am going to have deport this state as.
One for rock bottom before 405 generating with instruction that the war happens it so look at this once again state that now suppose are marching X and Y okay then if I just passed this some expressions using this rule what will happen first thing I would to say is a new tab corresponding E so what will be the new temp it generate E1 and then it will generate an instruction saying E1 code into a code now what is even code into code when another sparks in this.
And then I generate this inspection it will say t1 is a sign E1 place and where is E1 that is in X and what is e to bite so I end up generating an instruction into Sailor E1 is X +Y and that value will be stored in E code now when I pass this whole thing again I just say that I generated new temp so I can generate E2 and then I will say E 1 code now. What is corresponding to this that code is the instruction is generated and what is the code corresponding to this now and then I will generate one more instruction that will say e 2 is assigned T 1 + Z right so it will generate these two instructions on the right now good for say that I have a statement so if I say that,
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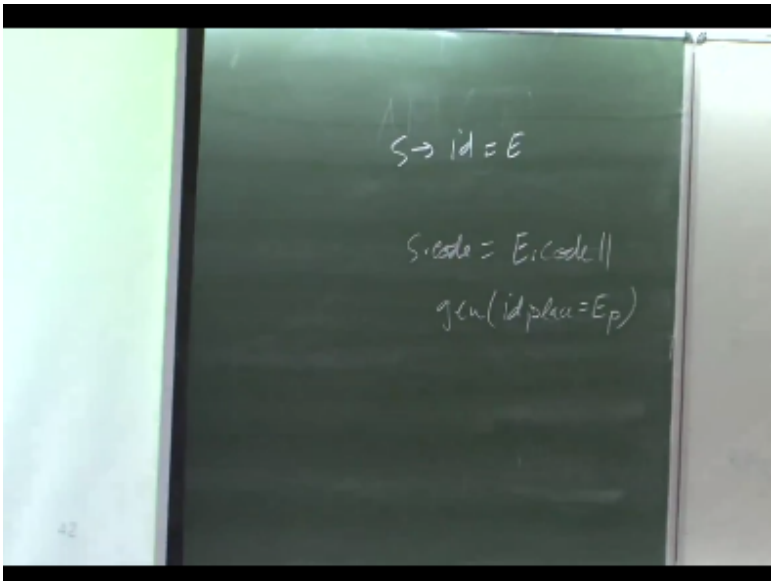

My rule is this something like this so I decide the sign equations and what is the kind of force sequence I generate it now so let us look this and try to write rule for this particular grammar what about to say. So I am not trying to figure out what might ask for my code this and do I need a place us this will be the place that we arritate do progress I do not return any place because that is a statement that I am fine okay so what in my X code in this case giving who is now that you have all the examples in front of you.

So let us go to so all I need to say is this is equal on technical bitch one more instruction I am definitely more than that one more instruction how you can get it I need to generate we can say that place is fine so now you see the third instruction which is being addicted that will be passed by this particular rule he has already been passed value of that is already is 42 so I generate the last instruction to say that ID places this and decode is already stored these instructions which is hey now suppose I write a new rule which says he goes to these party so I'm not changing my operators.

If I change the operator then we make a treat for this you same as the first one except that operator will kill competition to win it there are no other difference I call it making sense now over here maybe create this foot so let us now go through once we have understood this part let us go through the generation of we hit the score this is how or we look that if I am saying so we are already familiar with create this for this.

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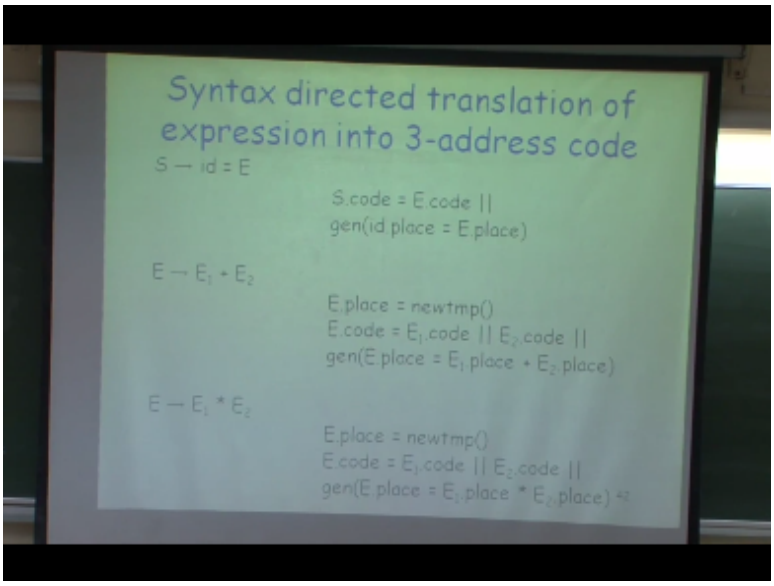

So I am not repeating that part so when I have grammar rule it says Eddie is a sign he then I am saying S code is nothing for a code followed by this instruction and if I have then I say that first I have to make a call to Newton we developed a temporary where this expression will be stored and then I say E code is nothing but even odd followed by you to port forward but generating in is instruction and if I say I have multiplication that will be repeated except that this plus we get it takes a modification okay.

Are you confident about that given stiff my expressions or any kind of expressions with no controls no move nothing I can at least by systematically at this point now that is a few moments so now suppose I have a rule like think that he is so he code is equal to so let us look this place and for so what do you eat this so he code will be just even poor and deeply even hints and what about this so I hope you get another instruction post or - and a detailed instructions are generated so far that means I need to give a part for instance that means if I need to generate one more instruction that means I need now a new temp.

So first thing I say is that he places the loot M and then I leave a dime for this evil court followed by and instructions will say that he places - B - so you may be negation so this is how much or good look he places new temp and B both is even followed by generation of so this is the example.

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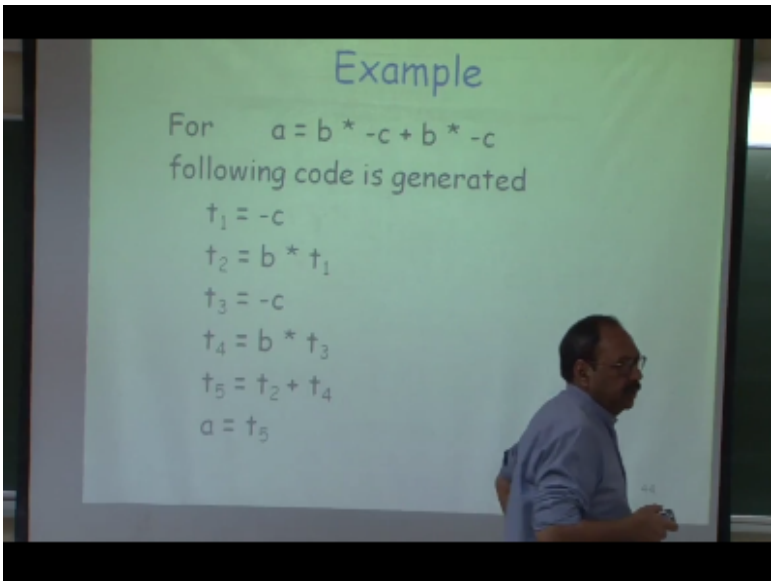

And suppose I need to get rid output for this by parsing all those first you can see that if I am sending my input from left to right yes I am and then first this unique C will have to be taken because this has so this will have the highest incidence then the multiplication will come and this piece spa - II will be evaluated this P *+ P will be valid and then addition will happen and so I end up getting old--like P 1 is being assigned by the sea and then P 2 is be defined B star P 1 so that gives me value of this sub expression I E to the same thing here.

So as I said I am not optimizing every region here at this point for France while Mao said P 3 is minus C and P 4 is P star P 3 which gives me value of this sub expression then I need to add the two and put that in a new temporary to say T 5 is e 2 plus 4 there any questions on this but this looks pretty straightforward as far as the invasion of fear that is worth one expression systems any complexity increases or something which is clear anything because there is something they are going to heavily used on your columns.

So it straight line expressions up here then I need to worry about close statements I have I have if then else is hydration but let us see first conditions now you can take code for conditionals only thing I need to understand is that what is the semantics of each of the statements.

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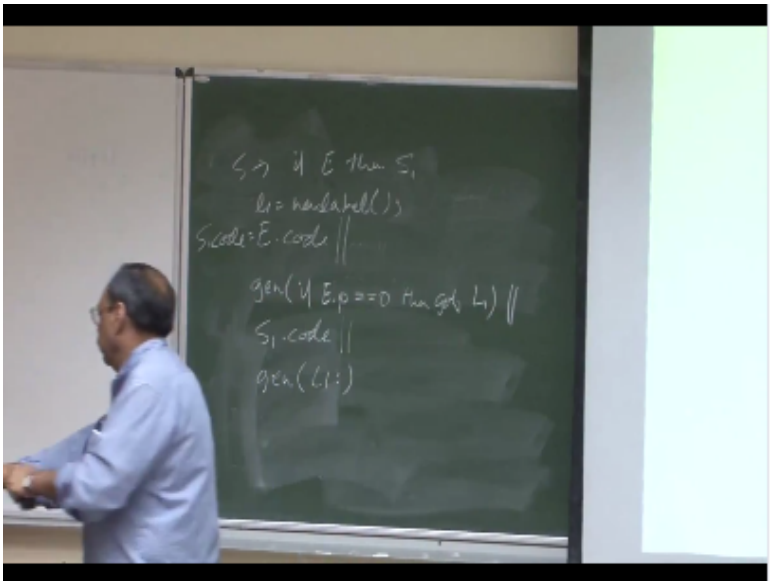

So for example if I say a rule which is of this form so called a house stapling it says if expression then so again I want to distinguish between this right E is goalie expression and for this but only thing I need to remember is that when code for this has been generated what is the place where this value has been stored because I so how is all of this loop semantically what does it mean basically what it means is that first time they make code for e then I check whether this is true or false if this is true then I will go and execute this code and if this is false then I jump to some level with this beginning of the next thing right.

So now would be Bay what the thing I need to know is therefore not worry about code for techno systematically generated if you know the syntax so we do that so first you will say is that I have some people so let me write S so this is now once I have code for e then what is the next thing I need to do I must check it for to a false now there is the value of the C code stored that is any place ok so now I need to generate one instruction if you say that if a place is equal to decrease is equal to true then what will happen and for S 1 so can I do it other way.

Now I am going to say that it which is false then jump to some level if this is to tended to just right so if this is false then go to after is then what is the after is I need to have redress I need to have a little wager that means now I need one more function earlier I was debating only temporaries now I also be cool debate labels so now let me say that L1 is L u label . L u label some function are used I also say that right so now you say that let us jump to L1 but if this value is true then what do I do now assuming that s1 is straight line for it has no control flows but even if it has control.

Flow I can always recursively generate code for this all I need to say that this is s and after that is going to be so I need to now generate one more instruction and I can say that generate now L1

right now does it cement Italy translate what I have captured here okay so this is really what happens,
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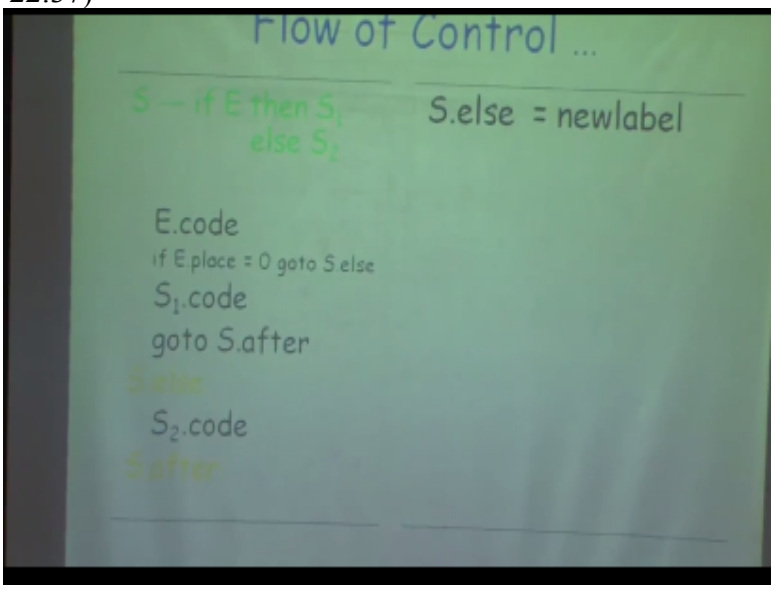

Interpol oh okay I started actually with a different example so since I started with white example X also okay so here is if that is actually a more general case of if that is so what will happen in this case I have two statements here one is s1 and another is S 2 and depending on whether this vacuum is either x 2 x 4 is now how this pole which I have just shown and S port these two things are so after label but instead of label so now you have to see two things okay that if I say that if this is true then depending.
On that I like jump on this or jump on this now depending on whether you compare it to 0 or 1 will be a false true statement another will be a jump either demo red spark depending upon whether you compare this with Y 1 and then I need to have one more level which will take me out of this page so that's the only difference that can happen is to say that this is false then I am going to a level which is corresponding to L spot which is s 2 and if otherwise you just fall through and execute S1 I do not t require related.
For that and if s 1 gets it stupid should I just fall to jump somewhere then I must jump after the speaker invested which I need a little there which is false warning who decide one and therefore I need to have a statement which will say jump to a label which is after s and then I say I have a label which is corresponding to s else where I jump here and then I have word for a school for jump No or some Pollock that is not displaying.
The other side of the truth so this is how this email below and if I now say that this is how the schema is looking then there are two levels which are being generated and I need to make those

with these blue so one of these labels these are I say that S else is a new label and S after is a new label so these are two labels generated and then I say S code is nothing but E code followed by this statement to say that if he places zero.
That I jump to this label that I have corresponding to S 1 then I generate now one more instruction with a jump to a softer then I generate this label and then I will generate code for S2 then I will generate S after right.
And this take here of fourth then i am only generating the label right now yes still not completed your question from your heart it is an issue so what happens okay so let me rephrase the question now what happens if the statement immediately after this has a label in the beginning what will happen in that case so suppose so let me go back and this for make one slide and then we will revisit the scene so let us go back to what we just skip and which was while statement now hay let us look at Y okay and then I will address issue okay.
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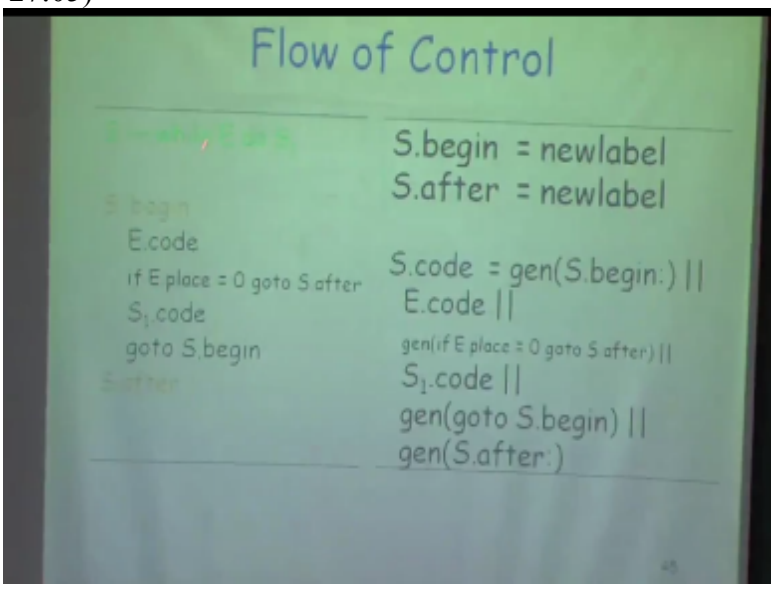

So how I generate flow of control now again what is it what is the schema what will cement is for this that first time I must generate code for this and if this is true then I jump and execute the sound it is after S1 and S2 it is not working I need to jump back to the beginning of file statement and be valid schema even when I keep on doing it and when even becomes false then I jump to statement which is immediately after a little all the labels do I need two letters one for the beginning of the statement another for the end of the statement right.
So this is how the schema looks that I have label at the beginning then I have code for E and then I say like if this is false then jump where softer otherwise and say S1 and then I jump to S begin so I will just go to this and, then I level this S after and if I note write it in terms of code how will

it look it look something like saying that I must generate a new label corresponding to this and I must generate another label corresponding to this.
So two labels must be generated and then I say that S4 is now just this schema which is generating a label begin then it has code for E so I still do not know how to expect the food for E but I am assuming that this part has already been processed so when we look at boolean expressions this part will be done here and then I generate this instruction which says if E place is zero that might jump us after and then I have code corresponding to S 1 and then I have both which is corresponding to this jump.
And then I have generation of the label okay now suppose after the general statement the next statement is Y okay so I am generating one label into other statement which says go to the beginning of the next statement and I am generating another label which is part of this Y which is the bigger so what happens if this thing else is followed by buy you I have two levels of the beginners of the Y statement actually yes there are two layers right if there an statement generate label but when control comes to this table there is no edge corresponding to that so it will fall to the next level.
That will work but that is a very inefficient we do not want to waste number of labels another issue is that when you are talk to of labels suppose I need to generate machine board and not assembly board so if your generating assembly board and labels are nothing but symbolic board you have done a assembler you have read something about the assembler yes no so how do I determine suppose I am assembling this program I am generating the machine code how do I find out.
So if I say here go to a softer okay what is it address go to a softer do I know this address this point of time I am not using all this name suppose I am assembling this is an assembling board and I say jump to a soft what are the PC value of going at this point of time yes no why do I got like what we weights me from moving it at this point of time I do not know how much code is involved in S1 write recursive education .
So when I am passing this I do not know how many instructions are going to be taken so when I say to defeating beginning of every class these white boxes on the remote election so if I do not know the address of this when we are finish this sentence I will lose its address only after I have deleted all this code right these are PC values that means what will happen is that this place we have to be Dutch actually black you will not finish this and this will be filled in afterwards after I have determine value of this label.

And we are going to use a technique for packaging so if I start using that pattern then you will find that this problem of particular this is vanished but in this scheme that I am not doing back patching say to parse assembly or two parse code generation then I will generate all kind production if this is a question or answer so these are two flow of controls statements we have okay that we can handle I am not going to every container so on.

Because so once you have understood schema for one hydration rest hydration are going application of sales here once you understood schema then all conditions except one which is A statement slight A statement are special and there is not different what will happen in the symbol table I am putting names now so two inspections earlier which I have generated and I now modify and say that.

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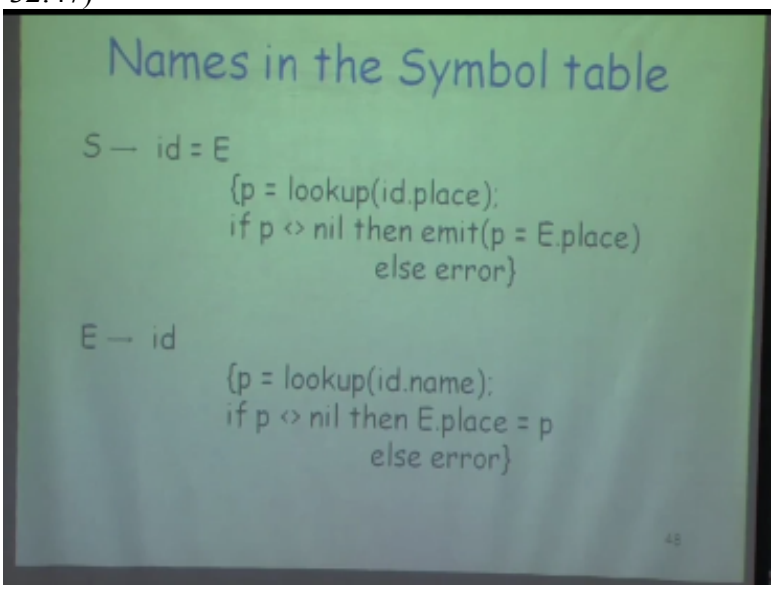

When I was so first when I wrote this I said E coded is nothing but ID place okay how do I know what my ID place is I have already entered it in symbol table so just I can do a look up and find out what is ID place is so basically it is return in a pointer so if I am just saying return the pointer to this and I do not have the name to this okay and the point is insufficient if it is not null that means this value is already being used in symbol table that I am going I mean this particular code okay.

If it is null that means it is very well not exist in the symbol table than I am going to give a null similarly when I say E goes to ID these are the two places where I mean to axis my symbol table E goes to ID look up this ID and if this ID is not null then E places P otherwise this is an error okay this is the only thing to do now check whether this value is already in symbol table I done know where I start parsing okay.

Now next thing that comes is so I handed some variables what happens in heaven and they have certain properties which are different than variables and one properties area status that all any elements are going to be given consequence locations in okay that means when I write something like.

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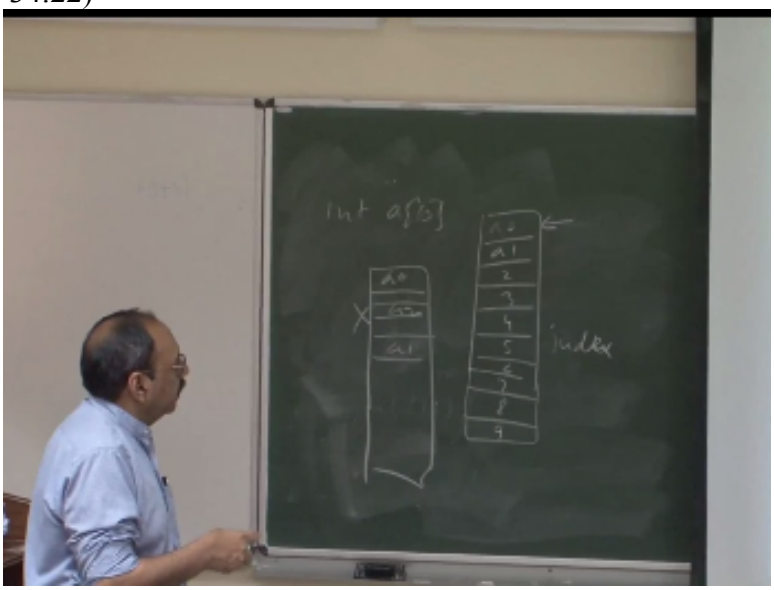

So if I have a declaration like in then what this means is are two things one that I am going to now allocate 10 elements which are going to be indexed by 0 9 if I am talking of C and depending on language the index values going to change but more importantly I say that I am now reserving certain space in memory which we have 10 locations so this is going to be A0, A1 ,23456789 this kind of location.

I have been soft I will not say that A0 is so my map is not going something like saying if this is my memory time if A0 is here than A1 comes here and then A2 comes here this is not I will be always on the now the cons equation location for all other elements are very then I need to know the addresses for each of these variables only thing I need to know is that is what my base address from where the through its past and got your life indexed by this to sufficient to find out in simple table I am only going to store the base address.

And whenever I say that and I trying to axis AI only thing I need to know is I and I need to know my base address now this part of this computation has to be pre computed and stored in a simple table for coordination.

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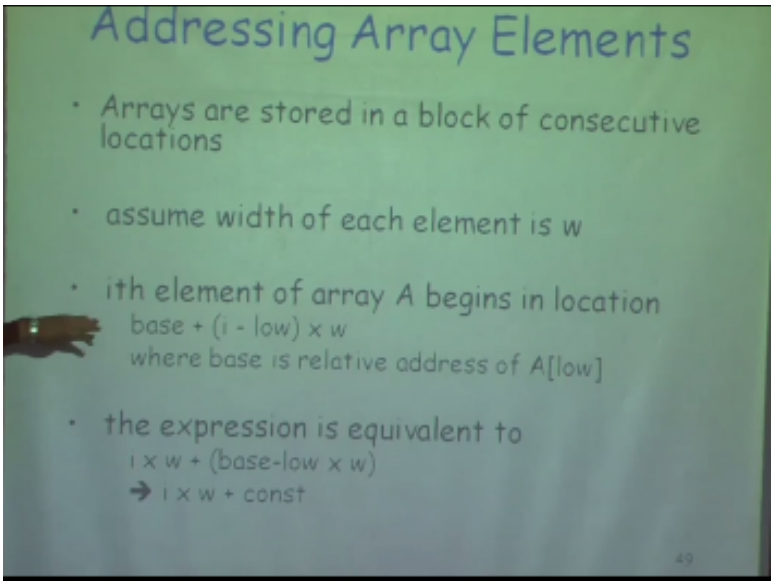

So what will happen is that arrays are used to be stored in a block of holes between locations which are like this and assume that width of each element disturbance that means from the type information I know that how many bytes each of these elements taken so if I say this is an integer then each integer has given 4 bytes then I know that it is taking 40 bytes that is the total address which is required now when I say that I have to find higher element all these are saying that I need to know my base address plus.

I need to know what is the no redex now depending on the language it could be 0 it could be 1or their language to say that it can permit me to have declaration is to say A is 10 to 19 so giving you more generalized impression which is saying I must know the lower index value then higher element can be found by saying take the base address find out the difference now you can see clearly that if is it 0 and the base address so for example if you want to know the base address of I then I just need to have 9 here and this will be vanished so that is what will happen.

That this the element so depending on the language you have to find what your low value is and if I now take this expression and sort of do some reorganization you can see that there is a constant part which is space minus loading to W and there is a part which is dependent on I and I can write it in this form now this constant base minus low into W this can be computed and can also be stored individually I do not have to compute with every time by saying that I want to find out AI address of the A I, I do not have to compute this part and I can just access this first and only thing I need to go through this, this particular multiplication

So if I go for two dimensional array problem becomes slightly more complex okay we generalized for so if I go for two dimensional arrays I say that has now so that is not worry about languages like C where arrays are going to be handled by pointers but in a situation like this and

I say that there are two dimensional arrays is going to be my compliment first question that comes is that if this is my A how do I respond to what is the order in which I am going to pick up elements can I randomly pick up this obviously no then do I go in this direction or I go in this direction.

So this is defined to either you are going for lower index storage or column higher storage I need so if you take four that is how is being to be stored this is called column buyer and in row buyer will be I will take element in this direction and equal scoring so obvious symptom see this axis pattern are going to be different because I am not zooming square arrays okay these could be different okay axis pattern is demanding upon whether this still I will starts with my base address here I suppose I say this particular element which is EIT now find out here.

That means if this is giving me row number and this is giving me column number I need to find out how many rows are before that then and multiplied by number of elements okay and that will take me to this base address than I say that how many columns are previous with them that is the computation I need to do find out the base address of yet right this is what happens and the storage can either be room major or column major finding upon the language you have and in case of 2D array stored in row major okay.

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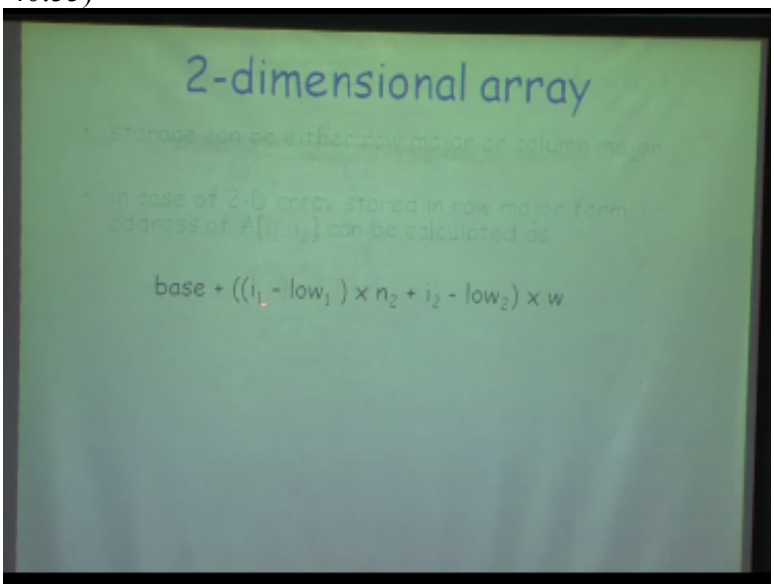

The column major you can do this computation okay DI 1 DI 2 or DIJ can be calculated in this form and it says this way then I say that this is giving me the row number I must whatever in the low index of I multiply by the number of element in each row which means number of column are so you have to see very clearly that when I am saying I am computing this I say how many

rows are before that and multiply that by the number of columns so he gives me number of columns are okay.
And then I say that for the second part I will take I to minus low2 which is giving me them this offset and multiply whole thing by W and what is W number of bites each element is going to take state expression again I can reorganize this so anyways this gave me column numbers and if I rewrite this expression this is how this expression will look and you can see that this part of the expression is constant and this part is the only one which depends upon I 1 and I 2 so after simplification you can see that this expression can be computed in hex also be stored in the symbol V okay.
So this is I would say that this is a constant , constant which is part of the symbol table so to find out the address of a I 1 I 2 this is the expression every time so if I now say that and this you can now expand to all right dimensions and also you can expand it to that instead of row major or column major than you can change this particular expression right okay so this symbol
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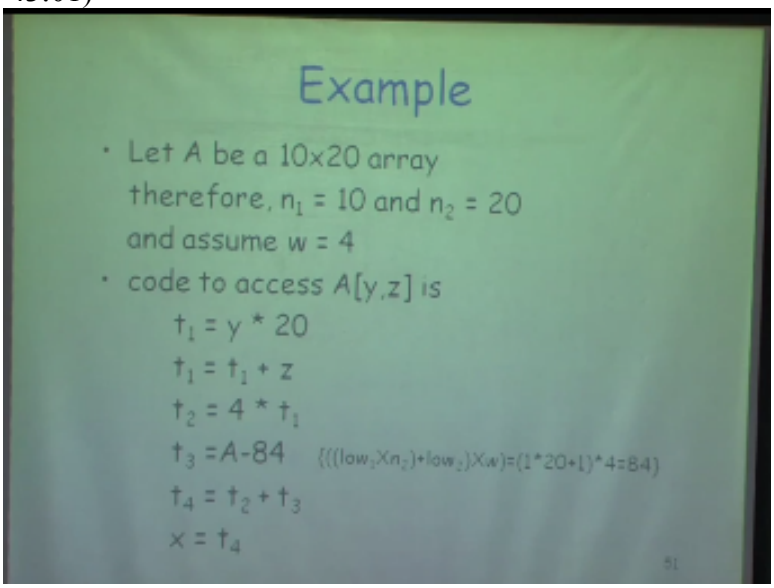

So as fourth generation what will you do that if I say that is some error which is hanged by 20 and I want to find out so N1 is 10 elements and N2 is 20 elements and I assume that W is 4 which elements take 4 bits okay and I want to access a Y Z so why is that out this is this is how much what we do and say that T 1 is Y star 20 so this is basically this part is the one which corresponds to computation off by insect and this part is T3 this is really computing this constant.
So I do not know what is A is this A will be and this when will I know this A and four-point-oh kindness is from to pick on is known to me to communication so whenever I say that any ages way to responding from memory then I will go the base address okay and that also is in the

simple table so I can then just compute this part and then I can and so you can see that this expression is not being computed every time I change so there is a clear this for only difference between available and arrays will be that we do business and therefore you may need index value address for each other is for all the beautiful surfaces yeah any questions on this okay.
So now let us look at one more T and if you recall at some point of time we started by checking and type portion and when we were doing type question at that point of time I poured in certain manner you recall I said.
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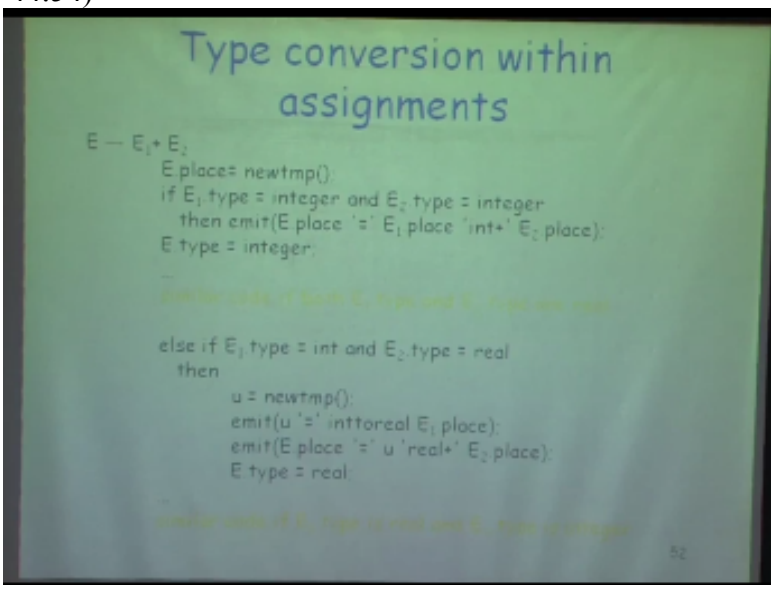

That when we have code in this form and am I said if this is int this is int then type of this is int and if this is float and this is float type of this is float again this is int and this is float then I wrote one expression by doing the kind of type of splitton the type version same thing now in terms of fourth generation what will happened that if I am not trying the code and say mixing of type is allow that means code E1 and E 2 is allowed but they obviously do in valid types.
Then the way I have to get the code is now I will check that if E1 type is a integer and E2 type is a integer then I am going to emit E places now I sign even places plus integer edition and E2 place and type is going to be integer now you can see the mixing along with the type checking along with the integer this is the reason if you recall I said that rather stand plugging it in just two clauses both are integer then this is integer and this is real okay I expect this into four separate cases okay.
This is what happens here okay and similarly we both are real and the same thing can be delta two are not same one is integer one is real and what will happen then I will have to write casting this internal potion so what will I do now for type casting or if you see that this is integer this is

real that means even has to be typecast it to real okay for this I now need a new variable and I say that I am going to emit now a code will you say that you will sign the real which is the function by cast even this.
So this interior has now been tricuspid too real and then I say that E place is nothing but you and real edition and E place so one more instruction okay and then I will say Theta it is real what will happen when this is real and this is Integer I just need to flick the order here and say that between the even place and you will be in courier of this place so I just need to change the order and I will get similar of this so now you can see that when it comes to real time in coordination okay.
I t is not sufficient to say that I will have just two clauses but I need to expand it in full four clauses and for each case I mean and this is also ensuring that I am generating the right I know operation so in this case I TR addition and this case I operate real addition and you know other cases actually arranged but in this case I am also generating now across the construction yeah any questions on this but I am only giving you that I am allowed to mix of the type of integer but if you say that I have my higher and in the same go for expressions one in one time.
And another in need two generator proper type parsers I am only my language is that E1 and E2 are integer in type now suppose you say that I integer to character it is also a expression so that is a restriction which not by the compiler the compiler either just intimating whatever language is my language says I am only along to mix the integer real then I am doing this that I just need to expect all these cases yet so let us take a break here today and all those who do not collect their answers in their previous class you can just collect from me.

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