Introduction to System Dynamics Modeling
Prof. Jayendran Venkateswaran
Department of Industrial Engineering and Operations Research
Indian Institute of Technology, Bombay

Causal Loop Diagram Part - 2
Lecture – 3.1
Guidelines to build CLD-III

So, we will continue looking at a Causal Loop Diagrams, introduce what causal link is and saying variables and started looking at some of the guidelines we looked at saying it has to be noun or noun phrases.

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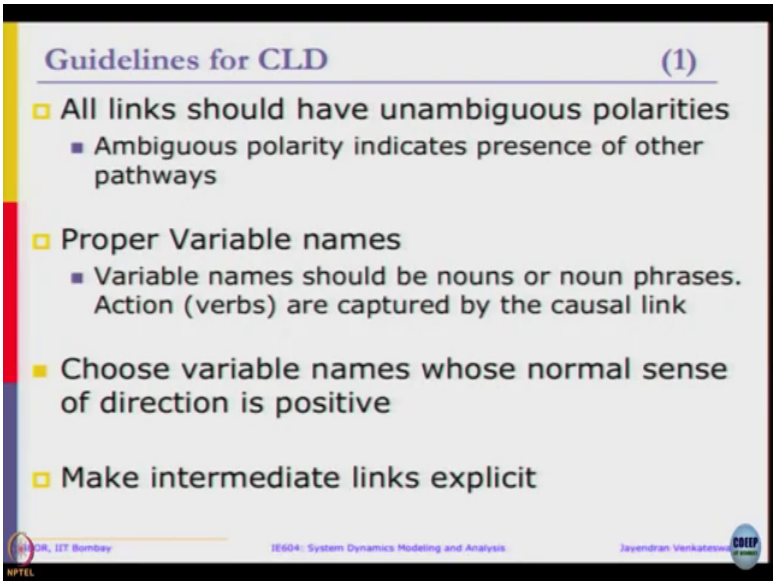

And an unambiguous polarities as well as choosing variable names is normal sense is positive. So, these are three guidelines. We saw there are a few more guidelines. It will also

be illustrated through examples like we did yesterday. So, today the newer guideline that we can look at to begin the classes make intermediate links explicit.

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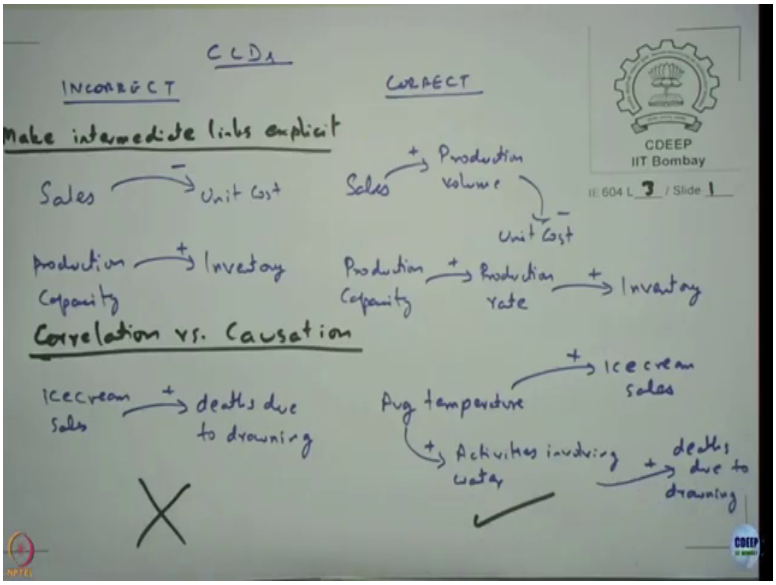

CLDs again I am going to draw the incorrect or less correct one on the left side and the correct ones on the right side of the page. So, what you are trying to see is say make intermediate links explicit like intermediate links explicit. For example, we may have a feeling that for example say sales can lead to larger sales can lead to reduced price. As the product sells more and more, then the cost of the product can actually fall down.

But if you just model it that sales results in a reduced unit costs, then you are missing some key element in the model. For example, you may want to actually say that sales larger the sale, it can have larger production volume which can result in production and the unit costs as a production volume increases, the cost comes down.

So, this option here is little more intuitive for us a the larger quantity we produced reduce costs. Rather than this one here that we are trying to link as there is a larger amount of sales because of which I am able to give you discounts things like that, but there is an intermediate variable here which now makes a little more extra notary, a little more intuitive to understand.

Or for example, if you want to say production capacity it can lead to increase inventory. So, we have large capacity. So, we end up having lot of inventory. These are come some of the phrases which the managers tend to use. There were large capacity with us. So, we ended up making lot of products and we are storing lot of inventory. It is just capturing like this and capacity is more. We are having a lot of inventory. We can actually say production capacity as it increases, it tends to increase our production rate which tend to increase our inventories.

So, its the larger capacity I can afford to have a larger production rate which can lead to increase inventory accumulation within specialities. So, this is what we mean by making intermediate links explicit means.

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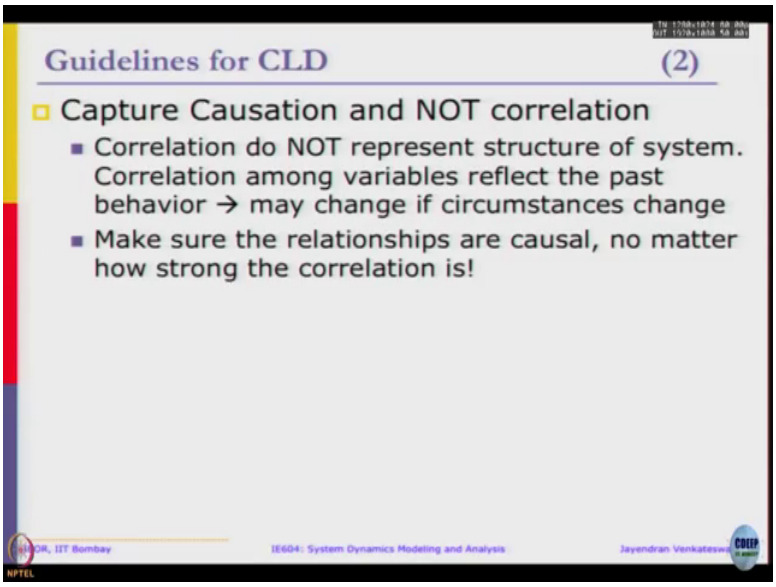

Its guideline capture causation not correlation. Correlation any two variables you can take x and y anything literally anything you need so much data set literally take and compute its correlation coefficient. It will give you some number does not mean anything unless there is actual causation between them we can make any sort of inferences, however stronger make sure the relationship is causal. No matter how strong the correlation is, you can come up with correlation almost any two variables.

For example since say since the 1950s or 60s, the atmospheric carbon dioxide has also increased, the crime rate has also increased. That does not mean that we identify variable atmospheric carbon dioxide and link it to crime rate, right. So, that is what I need. There are a lot of variables which are showing positive trends or the increase in ownership of cars and crime rate. They they may not have direct correlation among them just because it is there.

It is because there is a strong correlation does not mean there is a linkages or a common statements like for example let say now if there is the lot of firemen fighting a fire, that means it must be a big fire. That does not mean we write, we did I draw fireman and an arrow linking it to fire let me because that just this is not true and we got the direction wrong.

Correlation versus causation let us say let us say if I take a some the scenario like for example, in the summer months there is a lot of, there is an increase in the sale of ice cream right and in summer months there is more deaths due to drowning. So, we do not go ahead and say things like ice cream sales deaths due to drowning.

What we want to say is in the month of summer we have increase in the sale of ice creams and in summer there is more deaths due to drowning. You can forget the data set, you can definitely get a good strong correlation among them, but that does not mean that we say these things. So, as it all this side is incorrect side, but here when just listen to the narration that I am saying that all as there is in the months of summer, most sales in ice creams are being observed.

And in summer there is deaths due to drowning, but if you just only take data set we can show a strong correlation and so, we do not want to do this. What we instead do so perhaps let us say the average temperature can drive up the screen sales and increase in temperature can result in more activities involving water. Let us say should it lead to deaths due to drowning. It is pretty much what we wanted to cover. It is not the correlation that we are interested in, but the causation that is actually driving different variables within the system.

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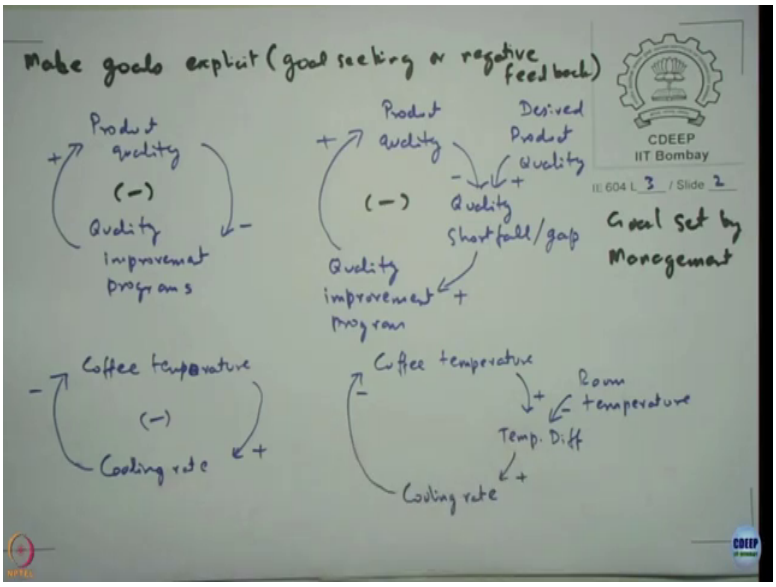

So, next guideline is make goals make goals explicit especially true for balancing loops or goal seeking systems or negative feedback loops. All mean the same thing. So, we want to make those goals explicit. It may again come up with some examples let us say product, a quality and quality improvement, quality improvement programs.

So, product quality is low, then we will have large number of quality improvement programs right. So, product quality is low we will have more quality improvement programs relationships opposite because more quality improvement programs happen, quality should improve this idea of quality improvement program. So, we can have a plus sign so, it seems fine.

But then how long do we keep doing it? There has to be some goals towards which we want to address the progress correct as I told this side is incorrect. So, all these will be defined by

the desired product quality. Product quality does not exist in absolute sense. It exists in a relative sense. All quality is defined. I am sure we can whatever a product you take there are some quality standards that has been mentioned and accordingly people will work towards that and spend corresponding amount of efforts. So, do you want to make those things explicit?.

So, let us just go ahead and do that product quality. Let us have desired product quality short fall, then we can have a quality improvement program. This link is the same. So, it had desired quality, product quality and the product quality I really want to see how different they are. It is my desired product quality, so pretty much I am going to take the difference between the so desired product quality as well as product quality you say and the shortfall is more then I am going to have a quality improvement, more quality improvement programs right.

So higher the shortfall, more quality improvement programs I am going to conduct, then you compare both are negative feedback loops. So, you can see there is only one negative feedback link here negative link here. So, this is negative causal link only one odd number. So, that is again continues to be balancing both.

So, this construct is kind of common we say whenever we want to have a goal, then we try to define a desired state of the system and then we try to measure the current state of system and take their difference or take their ratio or take their relative comparison identify short fall. So, this construct we can see in many models where there are some goals that has been defined. Assume the desired quality is here and actual qualities here. So, if increases the desired quality, the gap increases. So, instead of short fall let us call it quality gap, the gap in quality increases.

Here who determines the goal? No. So, who eventually who will decide for any product who decides it quality and we may select? So, eventually management decides. The goal is determined by the management, goal set by management pretty much they decide ok. There is a kind of quality I am going to produce and let us define that.

So, those are the that is an exogenous variable right here. So, they define it and based on that other activities happens and for different product ranges different companies they have their own standards and were against which they try to perform or try to produce and cook its not that all the goals have to be set by the management or these kind of systems we can even take a more simpler systems like buying a hot cup of coffee.

So, let us take that a coffee temperature and cooling rate assuming they are having a hot cup of coffee. Coffee temperature is high, the cooling rate is going to be high. As a rate is high, the coffee temperature is going to fall down. So, that becomes a negative feedback systems.

As I told the making goals explicit is really comes into play when we have a goal seeking or negative feedback system. It is all positive feedback. There is no real goal. We are working to it, but this is not going to hold true because coffee temperature is going to only cool down as much as your ambient temperature, right. It is not going to go beyond that it is a law of thermodynamics.

So, we have in this case we have coffee temperature, then we have room temperature, then we have temperature difference, then we can have the cooling rate. So, in this case if we just think about it we may have hot cup of coffee, we typically expect the coffee temperature to be higher than your room temperature, right. Coffee temperature is higher than your room temperature. So, we can put a plus or minus here because higher the temperature different, higher the cooling rate, higher the cooling rate lower coffee. We do not cool down faster until it reaches the room temperature.

So, here the goal is set by law of thermodynamic determines goals as I am sure you would have seen the simple equations on this and cooling up surfaces they are all differential equations. You can visualize them as a causal loop. They can even simulate it in the course of this lecture in a more fun way than what we probably learn.

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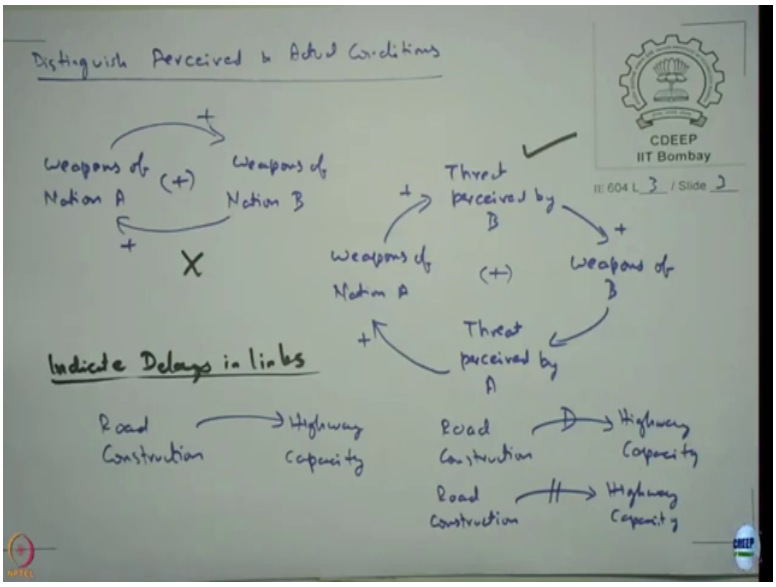

This is what we probably distinguish perceived and actual conditions. So, here as I told we are looking at more not just physical systems, we are looking at kind of socio-economic as well as environmental systems and what we are trying to model sometimes is it includes the behaviour of people, behaviour of the community etcetera. So many times our decisions are not based on the actual values, it is based on the our perception of reality.

So, we may need to explicitly model that to say to account for the lag between the actual condition which is what we are going to perceive and based on which decisions are being made that we can get an actual state. If we ignore the perceptions and ignore those kind of informations and beliefs, then what you are looking at is a very very highly rationalized scenario which is what is not working. So, if you are able to capture some of these

perceptions and beliefs and which we can do in our model, it will help in explaining and explaining certain phenomenas are trying to understand system better.

So, for example classical example here could be weapons race as one country gets more weapons, its a rival country is going to also increase its weapons and so on and so forth. So, this phenomenon and we classically call as a weapons race arms race or weapons race. So, we usually write it like weapons of say nation A, weapons of nation B as weapons as nation A it gets more weapons, nation B is also going to get weapon. Nation B gets more weapon, nation A is going to get weapons etcetera etcetera and it keeps going. So, that is what we classically call as arms race.

But a better way to explain the same thing would be weapons of nation A threat perceived by B such weapons A is nation as weapons increases the threat perceived by B increases. As they are perceived threat increases, they are going to invest more in weapons of more weapons which is going to increase the perceived threat levels by a which is going to increase the weapons of A.

So, the advantage of making these kind of perceptions and beliefs explicit is it gives us more options to identify the kind of solution, right. That is for example in the first case weapons A increases, then B increases there is no real way we can break it, but once we have here, we have no extra variables to play with ok. How do I alleviate the perceived threat of the nation?.

There is some other activity that I can do to ensure that the threat perceived by B is also going to come down because we need to know how to break this loop. So, that is essential thing that what we are trying to do because if you can see the positive feedback system, there is nothing stopping the system from growing exponentially which is what happens. There is something has to trigger to slow it down.

So, only thing is can we somehow come up with some still it is a positive feedback system. Maybe there is some other pathways which can lead to reducing this overall threat levels in such a way that the there is some sort of saturation or some sort of a limit to these kind of

growth in the actual physical weapons of some stoppage now. So, that is where distinguishing between perceived and actual condition helps.

Scenario is indicate delays in links it is again as I told you this correct. It will have an exponential collapse or accelerated decay can happen. So, again that depends on what is the threat perceived maybe the weapons reduce, but nobody but the threat perception continues to remain right. There are may be other factors. This is just a very illustrative example. So, unless we look at the full picture, we can have yes it will it only look at the numerical values and simulation can effect, then you can have other exponential growth or accelerated decay both ways the equations will work.

Road construction leads to highway capacity. This kind of make it sound like road construction instantaneously results in highway capacity, but it is not. So, on road construction takes a lot of time and after some time only your capacity is going to increase. So, we can indicate it two ways road construction highway capacity. We can put a D on the link or we can write the road construction highway capacity.

We can kind of put like this double dash on that on each link on a link. So, this link means that there is a significant delay before the construction completes highway capacity increases. So, this delay we know we can use a total duration to build it. Same thing goes for hostels, but when its reported is as if it increases students capacity there is so much it has added so much new system, but there is a lot of lag. So, until then the problem does not go. So, it is good to capture that the kind of significant delays within a system, ok.

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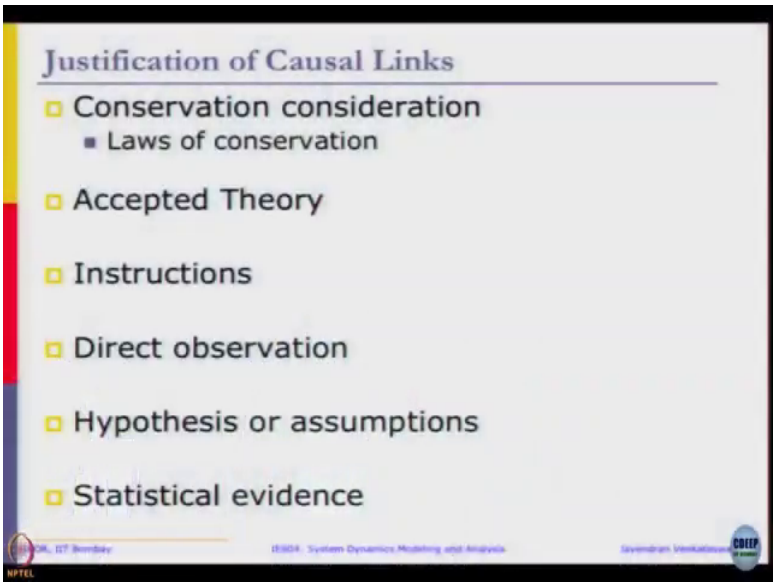

So, there seem some of the guidelines again. These are some basic instructions given. So, once you practice you will internalize it as we go along, but whenever you make the links you should come up with some justification why we are making some of those links your justification range from.

For example conservation considerations, the law of conservation must hold. For example, if you are modelling inventory, inventory is changing then we need to account for that production is affecting inventory say it is also affecting inventory ordering and receiving goods, affects inventory as well as consumption affects. So, we may need to model both. Inventory cannot just disappear let say loss of conservation has to hold.

We can follow accepted theory can follow economic theory. For example, in the common person and economic theory suggests that as price increases, the customer demand falls. So,

in an accepted theory we do not it may not be actually applicable everywhere, but modelling generic system that is a thing we start with there is no accepted theory. I am going to say that as price increases may demand effects expected to fall. So, then accordingly I can make a negative link there or it could be just instructions for modelling a manufacturing firm and the desired product quality is defined by the management.

So, you cannot argue saying that no this is too low quality. You can there is no need to argue there. There is a quality standard they have prescribed or if company has come up with say based on performance they are going to give bonus, so that is the instruction the company has formed saying that they if the performance reaches so and so level, then appropriate amount of bonus and incentives will be given to the employees.

So, we just have to capture that you know there is direct observation I do not know how many of you have done vegetable shopping and other things, but and you know it supplies more vegetable price immediately crashes down and supplies less price increases. So, we do not need theories and justification for it we are saying it. So, that is another way to do it. For direct observation also involves field studies and getting gathering the data and based on that taking a call whether it is a positive link or a negative link.

So, if the justification we are looking at is whether the link whether relation exists between the two variables and if serves is the link positive or negative for that is what we are starting with. Once we set the overall direction right, then we will move into what kind of equations to substrate. So, that is direct observation.

Class could be just hypothesis or just an assumption. We may not have verifiable data, but may be popular hypothesis. We are all used to making lot of assumptions to make a nice simple example like you know friction does not exist and then start modelling the system, all right.

So, if that is required, then we can go ahead and do that or for everything we may not be able to observe like for example it is I can assume that as oil reserves fall down, the cost of extracting oil is going to increase. It make sense. It is quite logical and making if that

assumption and then going ahead and modelling the access, so, those kinds of assumption is also fine.

Last on a statistical evidence I just told that correlation we should not use, but does not mean that we should not we should not ignore statistics. We have to observe data and if there is a correlation if there is a causation and then we can use the other statistical methods to identify the direction of causation within statistical evidence is also fine.

Anyway I think I got into this topic, right. So, and not very we already seen some of those examples earlier. So, I was just trying to write the similar thing again or I mentioned here. So, we just use these to justify the links. It is not that there is without drawbacks. There are some drawbacks.

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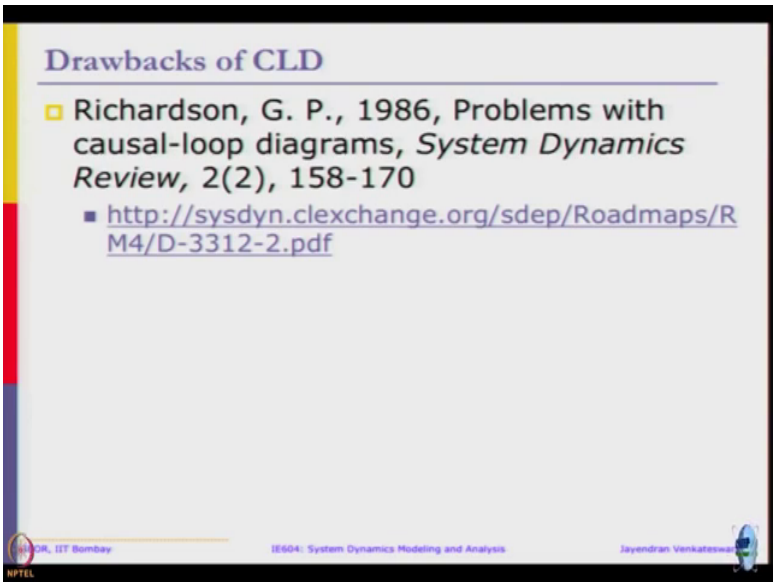

And it has been pointed out in many times of this causal-loop diagram. It tells us to be little more relaxed and whether we got the complete set and some of the scenario the model itself can become pretty complicated in short time. More such points are available in this link here. You can go ahead and try to see which are the scenarios that we can apply these kind of causal-loop diagram or not.