STD Session 3 (4)

**Karthik C:** [00:00:00] Little bit on discovery matrix, how, how to formulate that, right? Run you, run you through some basics. Okay, if you, I mean, unless you follow that, you cannot do assignments. Okay, I hope all the teams, all you guys have formed, right? Right, so that data, right, I will ask you to present. What I would like you to do is, right, all assignments, listen carefully, all assignments predominantly you will submit to teams, okay?

But teams, the problem is, right, it restricts on, Right, the type of file you can submit. What I would like you to do is, create a Google Drive folder. I'll circulate a Google Drive form along with the assignment, right? You submit, right, please understand, last year it was a big chaos, okay, so this year, right, let's try to do it properly.

What I would like you guys to do is, for every team, okay, create one Google Drive folder. Understood? For every team, don't create separate folders for each member of the team. For every team, you create one folder. Got it. And you give me sharing rights, myself and TS, [00:01:00] understood? Details, I'll put a screenshot, right?

I'll, many of you, what you will do is you will share a folder, you will not enable the permission. I will not even be able to go edit it, right? That folder, you will use it for adding any videos or any relevant document, right? That I'm not going to directly evaluate, but I will read through those information.

That you add to the drive. Then you share that drive link to a Google Drive link that I will share as part of the assignment. Got it? Any questions? So I repeat, what I would like you to do is, create a Google Drive folder, one folder per team. Okay. So going forward, I will give you assignments as a team.

Okay. So you have to, when you submit the assignment, what I would like you to do is, if there are let's say four people in the team, I need you to clearly define what was your role. Right? Chuma, if there are four guys, right, two people cannot just take rest and then ask, you submit. Right. That will not work.

I will ask you each and everybody. Right. Somewhere in the middle we will have a review. Okay. Maybe like [00:02:00] September end. Right. Maybe I will invite other professors. Right. Maybe in the evening time. Right. Last day we did. Right. We will run after five. Right. After class hours or on a Sunday or Saturday we will do it.

Right. On a Saturday. Maybe one full, whole day. We will sit and review our work. Maybe let you have nodded. Come to a stage where I can review your work, right? Still you are just, still sorting through your problem statements. So, I repeat, what I would like you to do is, right, now you have formed teams, create one Google Drive per team, and give myself and the TAs access to, to those Drive folders, right?

And any additional information, don't submit your assignments to that folder, any additional information, that's the problem that you are working on, any data that you find interesting, or any article, that's the problem. Right? That you cannot submit through Teams, you will use that. Okay? It will be a supplementary folder.

Understood? Right? Once you have worked for a month, right? Let's work through September, right? End of September or maybe starting of October, right? What I will do, right? If possible, on a weekend, right? We'll meet or maybe [00:03:00] after five, right? We'll meet, right? I'll bring in, I'll invite other faculty also to review your work.

Or we'll do one thing. We will take one class, right? We have got two separate rooms. We will call all of you, sit there, we will go, review team by team. I want other professors also to interact with your problem structures. So that way you get different perspective, right? I might say something, another prof will have something different to say, right?

So that way, right? You get a little bit of different perspectives, got it? Fine? So from now on, right, the assignments will be team submissions, right, after assignment 3. Right? And please make one submission. Don't make multiple submissions. If there are four people, one is enough. In the first page, put the team name.

Right. Roll number, instructions I will give you. I will give you detailed instructions. Ok. List down all the roll numbers. When you return the mark, right, right, I am maintaining a separate excel for your attendance and for your grading. Ok. Do not worry. If this guy is submitting your team members, you may not, I will not return for you, right, because you have not submitted.

[00:04:00] But you will be given, right, marks, but in the first page you have to clearly say what assignment, what was the contribution by every team member. Understood? Maybe one team member can take up data collection. One team member can talk about doing survey in different technologies. You understand, right?

Likewise, you can clearly tell me what was the contribution from every team member, right? If it is inadequate, I will return the assignment and say, you resubmit. Okay? Occasionally, we also do that. If the assignment is very bad or if I feel one person only, often that will be the case, right? Four people, five people will be there.

And only one guy will be doing the work, right? We'll return the assignment and ask you to resubmit in some cases also. Got it? Right? I'll go down, right? So you'll hear me from the ground floor. We have to resubmit. We have to resubmit. We want [00:05:00] everything.[00:06:00]

Um, uh, uh, uh, uh, uh, uh, uh, uh, uh, uh, uh, uh, uh, uh, uh, uh, uh,

What we want to do, we want to submit a Google, uh, Google Drive in the Google form. Uh, uh, link we have to share. Yeah, but, uh, Good [00:07:00] knees. Oh, the

Access or.

Engineer graphics for you

what [00:08:00] sound zero five transfer into the room.

No, it's not here. It's not audible. What is the problem with intensive directing? What is the, whatever the challenge, right? Whatever the challenge is, right? Look at the, right, the lady on the extreme left, right? There's nothing about it, right? She's working in social, okay? So the next day you say.[00:09:00]

Biology, chemistry, so, and there is.

Yeah. Yeah. Yeah. Yeah. Yeah. You are. Yeah. Yeah. Yeah.[00:10:00]

Okay.

So, students in H 1 5, I hope you can hear me. Right.

Yeah, please take it. May be sit for 5 minutes, because as I run through the slides, if there is a issue, you know. Okay, thanks a lot. Right, so, right, just as a recap, right, for students in H 1 5, right, so I will talk very slowly, right, because I cannot see you. I will be as slow as I possibly can.

Okay, so this is just a recap of what we saw last week, right. So, look at the lady on the [00:11:00] extreme left, right. She is working in. Sociology. Sociology.

Right? So, as you go, as you go to the right, right, we have arranged fields by purity. What is purity? Like discipline, right?

Right? As we keep going to the right, we have arranged the fields by purity. Now the problem with, right, what is called reductionistic thinking, this I explained last week itself. What is reductionistic thinking? Taking a complex science or a complex phenomena and then reducing it to one or two parameters.

What is the example we saw last week, right? I took the example of global warming, right? So, if I ask you. What is the cause of global warming? What is the immediate response? Right, immediately right, [00:12:00] greenhouse gases, CO2 emission, right. So what we have done? We have taken a complex phenomenon like global warming

and we are simply saying increase in CO2 increases global warming, right. So that is a very simple phenomenon. Simplistic and it is a what is called as a reductionist thinking. It is limited and it is narrow disciplinary view. Why is it narrow? Because what typically causes an increase in surface temperature?

There are wide array of, right, elements, influences responsible for increasing the mean temperature of our planet. What are they? Primary driver of the thing is what? Is the? Right? So if the solar output goes up, obviously your global temperature will go up, right? So this is not constant. The output from sun is not [00:13:00] constant.

It changes with seasons, it changes with time. Suddenly there will be a sporadic solar flare, right? Suddenly you will have peak solar radiation, right, for whatever reason from the sun, right? So that is not constant. That keeps changing, which means my global temperature is also going to change, right? That is the primary driver.

And what is the second parameter that you can think of? Maybe you can talk about distance, right? How close or how far am I away from the sun? That has got a influence, right? That is why seasons takes place, right? Summer, earth is a little bit closer to sun than in winter. That has an effect. Volcanic activity, right?

Often we are not taught about this. When there is an eruption somewhere, what happens? Volcano throws out all these black clouds. That blocks It, the comes into the earth and volcano itself can output millions and tons of CO2, methane and other gases also, other green house gases naturally, right, that has an effect.

So, [00:14:00] right, I can go on talking about, right, multiple factors, right. There are what are called deserted oil rigs, right. So how do we get oil, right? Typically we have something called an oil well. What is an oil well? You go drill, right, where is, you go to a place like Saudi Arabia or you go to Venezuela, right, where there is lot of oil, you start drilling.

There is something called economical extraction, ok. There will reach a point, right, for any well, right. There will reach a point, once you hit that point, what happens? It will become economically infeasible. You can still get the oil, but you have to spend a lot of money to get that oil. So, what they will simply abandon it.

Ok. So, abandoned oil wells will also release CO2 gases, methane and other gases, that is another source, right. So, if you say, right, CO2 causes global warming and what causes CO2? Automobiles, right, and we have got other home [00:15:00] appliances, right, and other human activity, ok. If I, if I have this purview, if I have this view, this is called reductionism, right.

Right. I am taking an extremely complex phenomenon like weather, for instance. Lot of parameters are there, see, don't get me wrong again, don't misquote me. Don't go and say Sarah is disputing global warming. That's not what I'm saying. All I'm saying is CO2 is a major contributor. Yes, there are other parameters in addition to CO2 that has a remarkable effect on global warming, and we don't consider them.

Why? Because it is too complex to model. Right? I have, it is easier for me, right, to take two or three variables, right? And then study its effect and then link, link them. So I reduce, I reduce the complexity. Okay, I repeat, I reduce the complexity, okay? Because I am not able to handle such a complicated phenomenon, right?

I don't even know, right? [00:16:00] You guys might have heard of butterfly effect. Have you heard of this butterfly effect? This is some thought process, okay? Somewhere, let's say, in Europe. There is one butterfly flapping its wing and that causes a small movement of air that has a cascading effect, okay, that causes a blow of wind, that produces a storm and finally there is a cyclone in Japan, let us say.

So a butterfly flapping its wing somewhere. Right? It's causing a cyclone in Japan. Is this, is this even believable? Right? You can, but, if the circumstances are right, all it needs is a trigger. Right? That butterfly flapping might have been a trigger, even though it's not the source. It might have been just enough to offset the balance.

Right? There are a lot of participating variables, factors, that causes some phenomena. Okay? Imagine you are standing at the edge of a cliff. You are carrying something, you are about to fall down, but you are just there [00:17:00] and I just come and give you a nudge, a small nudge, which is a very small force. In and of itself that has no significance, but given the situation where I can tip the balance, yes or no?

No, what happens? Right? That can have a cascading effect, right? This is all what we are saying, right? So this is what we call like butterfly effect, right? So this is very difficult to capture. In practice, so what we do? We take the majority, the most contributing factor, we take that and then we use that for modeling any phenomenon, right?

For instance, how do you measure population increase? Suddenly, Indian Statistical Institute, right? They, they do, right? They will say this is the average inflation rate. How are they able to say that? Right? How are they able to say that? They take some 100, 150 everyday products. They track the price over 2, 3 years and then they say, okay, average price of milk [00:18:00] last year was this.

This year it is so and so. Like this, they will calculate for 100, 150 commonly purchased items throughout India. Okay, washing machine powder, milk, sugar, dal, right. They will take an average of all this, right and then they will say, last year the average price was 100, now this year it is 110. You understand.

So, take the difference, okay, that is so and so increase in price. So, inflation is at 7 percent, 6. 5 percent. Is it the right inflation? The correct answer is nobody knows. Nobody knows. Okay. If you go to the population clock of India, it will tug, tug, tug, you will see increment counter. How are they able to do it?

Babies are born randomly. Suddenly if you track right, 100 babies will be born at this instant. Next 2 hours there will be no baby that is born. It will give you an impression. The clock runs, right, 1, 2, 3. That is not how babies are born. It will be random. Suddenly you will have 100, next 2 hours no baby. [00:19:00] So, what happens?

You take 24 hour cycle, you take the average number of children that are born and then you, you boil it down and then it appears as though every child is born every 2 second, 3 second. You get that sort of a mindset. That is not, that is not true. Yes or no? Right. And you again make a lot of assumptions.

Yes or no? Right. So, these things have a large bearing on how we model a system. Why am I talking about all this? Right. So, these things have a large bearing on how do you model a system, system modeling. Right. When you want to mathematically model a system, right, when you, when I want to predict next year 2025, same time, September, what will be the population of India?

It is, I have to extrapolate. Can I simply put a linear fit? No. I have to look at lot of variables, right? What is the immigration? How many people are leaving? How many people are coming into the country? How many babies are born? How many people are dying? Maybe next year, the mortality rate may be 0. 1 percent, we might have reduced.

That will have a [00:20:00] consequence, right? Like this, right, whatever possible that we can conceive, we try to accommodate. But there will always be something you will miss. So, that is what reductionism is all about. It is a useful concept. I am not saying it is bad. Reductionism has its role to play. It has got some meaning.

It helps me model a system to some reasonable extent, but At the cost of some error, right? There will be some error will be there. It is invariable, right? So, this is what we call as a limited or narrow discipline review, right? The next thing, next thing, next thing is called incom, incomensurability. What is this?

This I already explained in last class. It is called incompatibility. What is incompatible? For instance, ok, I am an engineer working in a factory. If I, if you ask me, I will ask for every possible technology that you can use. Me every possible technology. You want this computer I seven computer? No, gimme an I nine.

Okay. They gimme an I nine. They'll say, gimme a zon [00:21:00] processor. I'll keep asking. Right? So somebody has to put a check. The accountant will come and say, , no. What is it you want? Or you want I seven? I will only give you I five. Get the job done with I five. Why? Because deep Donny knows I will always ask something extra or that will be his assumption.

Maybe I need . Maybe my, what needs that? That fellow, what is he doing? What is his target? It is to reduce cost. What is the engineer's target? To reduce cost. But the way we do it is different. You understand? So now, what is happening between an accounts department and an engineering department? Engineering department wants a lot of money.

What does accounts department want? They do not want to spend money. So, there is an incompatibility, right. So, you take multiple disciplines, right. If you take multiple disciplines, there may be a chemist, some physicist, some engineer, everybody will say their, their field is important. Think about budget allocation.

How [00:22:00] does, look at the, how tough a thing, how the ministry has to deal with all this, right. When economic ministry makes an announcement, right, it is not easy for her, right. Everybody's going to blast her. Whether she goes a good job or it's a different question. Either way, she's getting blasted. Why?

Railway ministry will say, we didn't get enough budget. Defense will say, we didn't get enough budget. Education. Ministry will say, we didn't get enough budget. Right? They have to make sure they somehow spread the money. That's the quantum of available budget is so and so. The corpus is there. How do I distribute it based on some metric, right?

Based on some calculation, some model, again some mathematical model, right, again they will resort to some sort of directionistic thinking and that will lead to, into conflict between multiple disciplines, right. You understand, right, I hope, right. And you have to deal with all these socio technology problems, right.

What are you looking for, right? This we saw.

Sitting, somebody who [00:23:00] is used to looking at traffic management, right, now that person, right, that fellow is getting an insight. What is the insight? Okay, there is a natural waterfall, water flows, okay, this is similar to my traffic flow, right. So, that is what we call as an insight, okay. Some person who does vehicular traffic management planning, right, for instance, what is vehicular traffic management?

You want any signal, you want Right. Red light will be on for some time. Then you'll have green light on for some time. How do they decide the timing? And actually if you see, the timing will be different for different times of the day. How do they do that? They have to actually model school time. Morning, nine o'clock, right?

Certain routes will be busy, so they'll actually dive traffic again. Afternoon traffic will actually go down again, five o'clock. Everybody, all offices will close. All the schools will close. Again, there's a spike in traffic till 7, 7 38. After [00:24:00] eight o'clock, what happens night? 10 o'clock traffic would've completely slowed down.

What do you do about the traffic timing of the traffic signal? Now you actually turn off cities. If you go, they'll put the yellow light, they'll turn it off after 10 o'clock, seven signals, they'll turn it off. Why do they do that? Right? They want free flow. Hardly any, any vehicle is moving after 10, right?

So some guy who's doing that right is doing a traffic management and it's seasonal. Why is it seasonal? May month. What happens? Holiday vacation time. Children don't go to school. Mid of April, all exams gets over. Now, I have to program the traffic light. I don't know how much of thought you have given this, right.

Dynamically based on time of the day, week of the day, Sunday it may be different, right. Weekdays itself, if it is a holiday, it will be different. Otherwise imagine, if it is a constant timing 9 o'clock, right, 120 seconds if you have to go and wait at the red signal. If it is a Sunday, hardly there are four vehicles.

You will be cursing, right. Why is, why am I being, what There is nobody [00:25:00] on the road and I am being asked to wait for 2 minutes or 3 minutes whatever, right? Often you do not even think about it, right? So this is one modeling, some mathematical modeling, right? Somebody is doing this. Now they are looking at a different field, right?

Why am I looking at a different field? Often you look at another field for inspiration. What is inspiration? Last week, right, I discussed about the concept of biomimetics and bioinspiration, right? Just to quickly recap, what is biomimetics? Mimetics is mimicry. Okay, I am mimicking something. Let me write it down at the top.

When I mimic something, I am literally copying it. When I take inspiration, inspiration is different.

Okay, I am having some difficulty with my drawing board, right. So when you take inspiration, it is different, right. Here I am talking more of, analogy is more of, right, drawing a parallel. What is drawing a parallel? It is [00:26:00] like this here. If I look at it elsewhere, it is similar and they are comparable. For instance, ok, I will give you an example.

This guy's face looks like rose. What does it mean? His face is red. Rose is red, right? Is his face rose? No, I am giving a comparison, right? Somebody is angry. Man, you are looking like a volcano. You have so much anger, right? I am drawing a parallel. I am giving you an analogy, right, a comparison, something to something.

It is like one is to one mapping, you understand, right? So, when you talk about bio mimicry, right, look at birds. Is aeroplane biomimicry or bioinspiration? Right, it's inspiration. All of us agree it's inspiration. Why is it inspiration? Because birds flap their wings, right? The example I gave you last week itself.

Planes don't flap their wings. You have fixed wing aircraft. There are planes which actually flap their wings. They are called ornithopters, [00:27:00] right? They are, they also do exist. They are very inefficient, right? So, that is difference between biomimicry and bioinspiration, right? So, if you want to solve a problem in one domain, you look for inspiration or at least you start with an insight.

That is the first step, right? You start with an insight saying is there a similar occurrence elsewhere? Can I look to inspiration elsewhere? Because why, why am I doing that? If I say, if traffic flow, traffic flow, right? I am at the concept mode, right? Let me go to the next mode. If the traffic flow is analogous to water flow and if somebody has already done.

Modeling mathematical modeling of fluid flow. I don't have to sit there and do modeling for traffic flow. I can use the same principles, whatever that is there. Here if I can do that right Then that is what we call as iso. What is iso? I have a rigorous mathematical formulation here and here. There is a one is to one mapping [00:28:00] between both that fits.

If I can achieve that, then I am set to have had one scientific model that will actually describe both. Got it. So, what is the point of this, right? This is just an example, ok. What are we looking for? When you are faced with a problem, right, even take your own problem for instance that you are trying to solve, right, it is not a new problem.

Why? The solutions face my life, my clients elsewhere, ok. Imagine, right, I work a lot with medical devices, ok. Imagine your heart valve, it opens and closes, ok. If I have to design a new heart valve, ok, We have to provide a replacement. What do I do? I have to look at how a human heart works, right, and try to make a replica.

Can I make a replica? It's not that simple. So, what do I do? End of the day, it's a valve. Where do we have valves? Water pipe, we have a tap. Can I use [00:29:00] that idea? So, that is an insight. So, I start there. I do not know if I can use that. That is just an insight I have. What is the next step? Right. So, let me clear the board.

Right. So, what is the first step? Another example I am giving you. Right. So, I want a artificial

heart valve, right? This is the problem I have. I am here in this domain, in the domain of medical devices. I am here. This is the problem that I have. I am trying to solve. Now I can start from scratch, right? Spend all the energy, right? Or I can look at a similar field. Where do I have valves? I can ask this question, right?

I have valves in my cycle tyre. Yes or no? I have valves in my pipe tap. Any other valve? Right? All this is there. Now, I am looking for a specific valve. What is a specific [00:30:00] valve? Artificial valve is what is called as a one way valve. Now, so between the pipe tap and the cycle tyre, you Calculation with the transform on the other hand.

What is F t slash? F dash. Problem number 12, Calculation numerical and numerical transformation problem. It can be done whether it is functional or it is for practical use. So, there is something similar. It is not the same thing, right? Here I have a valve, here I have got a tube, but both are comparable. It is analogous, fine.

Next, I am going to rigorous formulation, ok. What flows inside a cycle tube? Air. What flows inside your heart? Blood. Now I have a problem, [00:31:00] ok. I cannot achieve isomorphism. Why? There is no one is to one mapping, ok. So I deserve the idea, ok. Then I go look elsewhere. Like this I can go on exploring, right, to look for an insight in a different field which uses fluid flow in one direction.

You understand, right? So that is the whole point of doing all this, right? So in general, right, last week's lecture we concluded with, right, advances especially the evolution, right? Where did all this systems theory, how did all this come from, right? How did this come into being, right? Technically, what is called the pedagogy?

How did this come into being, right? So, it came, first they formulated what is called systems theory. Where did systems theory come from? Cybernetics, right? Cybernetics is what? It is all about communication, right? There are [00:32:00] multiple systems, multiple systems talk to each other, right? So, what is the concept of cyber?

Cyber physical systems, have you heard of that word? Cyber, cyber crime, what is cyber crime? You commit a crime in the cyber space, what is cyber space? It is not a physical space, it is not tangible, I cannot go grasp it. It is just a concept of inter connected computers or inter connected systems, right. I am doing something nefarious there, it is termed as a cyber crime, you understand, right.

So, People from different areas, right? People from after World War ii. Look at the timeline here, right? It's 1940. When did World War II and 1945, right? So 1945 is when, when it ends as US was fighting, right? From 39 to 45, right? Six long years. They've been fighting Six, seven years. They've been fighting.

Fighting now. And they are doing it, right? All the allied powers, right? So, they were developing their own systems. They were developing their own systems, right? To basically have [00:33:00] an upper hand. What is upper hand, right? Today, right? Today if you have to win a war, what should you do? Let me pose the question this way.

Should I go bomb somebody? Yes. Yes, sir. I will tell you how vulnerable we are today. Okay. There is only one thing you have to do to shut down civilization. What is that? Bomb. Not even communication. It is even simpler actually. So, I hope, uh, students in H1 5, right? All CA students are saying, sir, let's shut down the internet.

Yes, exactly. No, there is something even worse. Turn off electricity. Okay? Cut I don't bother. Ok. ether and nothing can happen. Even the antipolar can come. See our system that is the worst case scenario. Even if it is a digital currency, there are proponents of digital currency, right? It is very convenient right?

All of you use jipe. But we forget the fact, we forget the fact, there was a Microsoft, right, one of the contractors, right, if I [00:34:00] forgot the subcontractor, cloud strike, right, there was a cloud strike failure. All the airports went down in India, they were writing boarding passes by hand. It went down for a couple of hours, not even a day.

Imagine the chaos it created, right. Imagine a major power grid failure. What is the power grid failure? We have got a, another power plant here. Kalpakkam, there is a thermal power station. Kudungakulam, there is a thermal, sorry, nuclear power station. Right? Neyveli, there is a thermal power station. These are the big power plants in Tamil Nadu.

And of course, you have got a lot of solar windmills, uh, near the south. All this is interlinked. All this is connected. Right? Now the robustness of the system is guaranteed. Then what are, if you have a complex set of nodes, okay, look at, look at this, right? So this is the central, there is no central node, okay?

That is the, that is the beauty of a distributed system. Skynet, right? All of you have heard of Skynet. [00:35:00] How many of you have seen do what is right? I, I, I don't know if it's, uh, Part 2 or Part 3. Finally, right, these guys will go to destroy Skynet and only to find there is no central server. Skynet is distributed everywhere.

So, they actually, they, they lose the war, right? So, the machines win, right? That's the, that's the premise of that film, right? Part 2 or Part 3, So, if you look at that, right? Don't get caught up in the movie. The reason, uh, right, I think she really means it. You are not feeling well? Go wash your face and come.

Right? So, the premise of the movie, think about the premise of the movie, right? That is the important. The movie carries a very central message, very applicable to what I am talking about today. It is, if you have a very large network with multiple nodes, right, with thousands or probably millions of nodes, if a few nodes go down, what happens?

Nothing happens. System will run, no, no issue, [00:36:00] but you will have an election capacity. Okay. How many of you know, right, let me quickly draw the, right, map of India, right. I am not sure where, the Hollywood map, right. So, right, southern peninsula I am drawing, right. So, there is a line that goes from Chennai to Singapore.

Okay, I2CYN, it is a fiber optic cable. From Bombay, there is another line that goes. And from, I think, uh, Tuticorin, I think, from southern part, right? It goes to Sri Lanka and from Sri Lanka it goes everywhere. If you actually look at the fiber optic network of India, right, everything is connected. But the number of lines that run are actually just like one or two dozen, that's it.

That is a, actually, after the class, I would encourage you, go, Google the term, world fiber optic network. And there is a map that beautifully tells you all the connections that run. If you have to cut off India, if I severe the line that goes to Bombay, entire west region is gone. If I cut off the line that [00:37:00] goes to Chennai, entire east is gone.

You understand? That is how vulnerable we are, right? Sometimes what happened, one year back there was a ship that put an anchor, anchor hit the line that comes to Chennai. What happens? All the traffic that comes from, all the way from Japan, Singapore, Hong Kong, China, Now it has to be rerouted through, right?

S Lanka, it has to be rerouted through. Other thing, you will have capacity, but there is some redundancy. Now the path is longer systems overall performance will go down. Okay? This is better than having one single connection, right? What I'm trying to tell you is when you have a lot of interconnected nodes, if a few nodes are a few linkages, right?

I want you to learn these terms today and. k, c, okay. I am going to define these symbols, okay. N is, right, nodes or elements, okay. Please write this down for me. I am going to use these throughout the course, okay. N is [00:38:00] nodes or elements. K is relationships, okay. K is the number of relations, okay. How many number of relations are there?

C is the content, okay. I will be repeatedly using this throughout the course. C, n, k, c. n is how many nodes are there or how many elements, right, however you want to look at it. And k is the relation between these nodes. There are, look at this, right, this is one node, this is one node, right, this is connected to this, this is connected to this, this is connected to this.

There are multiple nodes. So if you count, right, how many nodes are there approximately if I count, maybe 30. I am not counting, I am just eyeballing, right. How many k's are there? Look at the number of lines. Every line is a relationship, right? So, there may be, I do not know, 20k, right? What is the content?

What is the physical content or, right, what is the information, right? That is what C is all about, right? So, this you understand, right? Understand the vulnerability of a system to failure. When you have a complex network, [00:39:00] right, there are what are called the critical linkages, right? I told about K, right, the relationships.

If you see here the critical link, you can actually bring the system to a stop, right? What is the critical linkage? You go to the A value, look at the main feeder line, cut that. Okay. Huge capacity is gone. Now what happens? System has, there is something called brownout. There is blackout and brownout. What is brownout?

Purposely, if the demand exceeds supply, government will automatically cut power. Have you seen that? In summer right here, when everybody turns on air conditioner, government will actually turn on. You will be cursing, right? Why is, uh, why is the power, uh, TNAB, why is this fellow doing? Electricity, When you pull in more current than what the plant can produce, they'll actually turn off the subject.

Right. Why? Because you have to balance the power production and consumption. You have to balance, you understand? Right. So systems here evolved from multiple domains of different [00:40:00] nodes talking to each other. What are those nodes, different disciplines? What are those disciplines? Biology, mathematics. What is the foundation of computer science?

It is mathematicians. Right? Have you seen the introduction to the movie, A Beautiful Mind? Watch a movie, it is called A Beautiful Mind. Beautiful Mind. A Beautiful Mind. Beautiful Mind. A Beautiful Soup. A Beautiful Soup. Python Library. Okay. So the introduction, right? One professor will be addressing a class.

He actually says mathematicians build the atomic bomb. Mathematicians build everything. He is true to a large extent, right? The world is built on mathematics, right? So, guys at the last row. So, right? So, if you, if you look at, The evolution, right? If you look at, right, mathematics in its core, right, that forms the basis for most of what we do, right?

Now, why am I referring to this, right? [00:41:00] Look at the evolution of computer science. What is computer science end of the day? It is, it is not just coding, right. I often keep repeating, repeating it to students. If you are a programmer, don't think of yourself as a programmer. This point I cannot drill out. I am repeating it multiple times throughout the course of this lecture.

I will keep saying that, right. Your piece of code is a set of instructions that can actually kill somebody if it, right. Example of a nuclear reactor. Right? Look at, okay, false negative. This is the biggest dangerous condition that can happen. What is false negative? False positive is also okay. Okay, what is false negative?

What is false positive? Think about an Apple Watch. Okay? Apple Watch is a, it's not a diagnostic device, it's a more of a lifestyle device is what, right? Apple says. Now if you look at Apple, it will monitor your heart rate. It monitors heart's rhythm also. Not only the number of beats, what is the profile [00:42:00] of the beat, right, that lumped up, right, that systolic and diastolic beat.

If it finds some sort of disparity, some anomaly with the beating of the heart, what Apple Watch will tell you is, There is a condition called Arrhythmia. Rhythm becomes Arrhythm, Arrhythmia, ok. Arrhythmia. Arrhythmia. Arrhythmia. Arrhythmia. Ok. So, rhythm becomes Arrhythm, ok. Arithmetic, sorry, opposite of rhythm.

Arrhythmia means your heart is not beating properly. It is now starting to twitch. We call it as twitching. Your watch actually can detect that. And there is something called onset. What is onset? It is about to happen. The problem has not started, but I know beforehand. It is like tremor, right? When there is an earthquake, there is something called a primary wave and a secondary wave, okay?

There is some, so that is what people used to give [00:43:00] advance warning. Japan, right? Before 30 seconds, right? If there is an earthquake, how are they able to give a warning? The secondary wave is what will actually cause destruction of buildings. The primary wave is in low amplitude. So they detect that. They know, okay, fine, next 30 seconds we are going to get a huge, a huge earthquake is going They want sirens to go off, right?

Trains stop. They have systems in place. Now similarly, this medical condition can also be forecast. You can actually say, this is going to happen. Okay. And that is called onset. It is about to happen. Okay. Your watch can look at pattern and then if there is some disparity, it is going to say there is a likelihood you may get a heart attack or you may get something serious heart condition.

It can warn you. What will, what will you do? Oh my God, something is going to go wrong. You immediately go to the hospital. Let us say it made a mistake. You are all right. And it sent you to the hospital. Okay. What happens? It's a [00:44:00] nuisance. It's an inconvenience, but rather you went to the hospital. Let's say it makes this mistake once a year.

It's okay. If it does every day, then you'll ignore it. It's like the boy who cried wolf right? It'll become that story. But, ulta, this is false positive. And now it's false negative. Let's say you are getting an erection. And the watch does not detect it. It's a bad thing. What happens? You will die. You will trust the watch.

That is why Apple does not Classify it as a medical device. They say, we are not responsible, right? We have, have something in place and you are responsible, right? That is why they do not sell it as a medical device. It is a lifestyle device. If you want to work out, right, you will try and tell you a heart rate, ECG also can give you.

Ambulance can even give you ECG. But it says, do not trust it. It is not a medical device. It is not FDA certified. You understand, right? So, Why am I talking about all this, uh, tangent story? Somebody is [00:45:00] going to write an algorithm, some computer science engineer, some electrical guy or even a mechanical guy might write a piece of code to run on that watch.

If your code messes up, you can kill somebody. It's not one, it's many. Please understand that, right? We have ventilators in hospitals that, that uses a lot of embedded systems. We have lot of other what are called life, uh, that are essential.

I forget the exact name, right. If you go to operation theatres, you will have critical care devices, yes. You have lot of critical care devices that actually run a lot of these codes, ok. So, your code may run in a banking software, it may run in an electrical system, networking system or it may go to a medical device or it could be a medical database, could be anything, ok, right, you understand.

So, it is all about It is a network of interconnected things. It is what is what we call as an assemblage, right, an assemblage. [00:46:00] Okay,

note down these terms. I am going to be talking about this in the upcoming slides, right. I am just priming you for what I am going to talk, fine. So, is everybody fine, clear? So, I will give you one long ten minute break, maybe I will take for another twenty minutes, give you one long ten minute break, then we will come back, take the finish of today's lecture.

So, this is fine. So, just to quickly recap what I have been covering last 45 minutes. Right? We looked at the process of analogy, taking knowledge from one time point, taking knowledge Comparing it to another and seeing if we can draw parallels and then coming up with a unified scientific model, a rigorous scientific model, understood, right?

Okay. So, Now, let us talk about language of systems. Okay. Today I will give you a formal [00:47:00] definition for what is a system. We have been talking about systems thinking for design, right? I have not defined what a system is so far. This is the fourth class. Yes or no? Right? This is the fourth class. I have not told you what a system is so far.

Right? I am going to give you a formal definition for what is a system. Right? We will talk about that. Now we are going to talk about what is called the language of a system. What is a system and what is language of a system. We are going to use a measure, right, called complexity. So when you first hear this term, complexity, what is the first thing that comes to your mind?

Complex. Oh, it's complicated. It's not simple. Correct? It's the opposite of simple. Yes. Do you want complexity? If I ask this question, most of you would say, no sir, I don't want complexity. But I would argue, you need complexity. If everything is simple, the world cannot function. The world needs complexity to function.

Okay. Let me give you an example. Okay. Let's take our own human body. Okay. We [00:48:00] will talk about something from now. Metabolism. I will keep giving this example over and over. Microchemical metabolism is called metabolism. Arrhythmia. Right. Let me clear the, right. Let us look at, right, your body's natural glucose maintenance mechanism.

Okay. Generally, if you see your blood sugar level more or less has to stay the same. What is sugar? Sugar is the fuel, right? You need sugar to operate. All cells need sugar to operate. If there is less sugar, what? You will actually faint. If you have more sugar, you will actually, it will destroy the organs, right?

You need to keep it at a set level. Now, you will take food in random intervals, yes or no? You eat in the morning, afternoon, night, in between you may have some snacks. Suddenly you will feel like drinking one bottle of Coca Cola which has got insane amount of sugar. Your body needs to have some regulatory mechanism.

What is regulatory mechanism? Something built in mechanism that has to maintain a [00:49:00] set level irrespective of the supply. Suddenly I might go hungry, I might do, uh, right, fasting for one day, complete day. But you are able to function. You may be tired, but you are still able to function. How come? How is it you are able to do that, right?

Your body has stored fat. It is in liver and other parts of the body. That gets converted into sugar. Okay. Okay. Any excess sugar will get stored in the liver. If you work out, that is why when you work out, why do people become thin? They end up burning all the stored fat, right? Generally, if you want to become thin, what is the first thing they tell you?

Reduce your calorie intake, work out, work, run, jog, drive, go, exercise, right? So there is a natural regulatory mechanism in place that takes care of maintaining a set equilibrium, some sort of what is called stasis, right? Some form of a set level. So, when you eat, right, digestion process takes 2 to 3 hours, it is not immediate.

So, but when you eat, you feel good, how come? I just ate, sir. [00:50:00] Now, I feel fresh. I just took a cup of coffee. It takes a lot of time for the coffee to go, get, get absorbed through your stomach and intestines, get into your blood stream, takes a lot of time. Immediately, when you take something, right, some food or something, your body, there is a signaling mechanism.

It releases the stored energy. It is not the food that you ate that gets digested. Send it to your bloodstream. There is a signal pathway that says, Oh, we've got a fresh intake man, release the stored NNC. Right? It releases. Now, when it releases you also need insulin, right? That has to go in proportion.

Right? If sugar level goes up. Insulin, right? Your pancreas has to secrete more insulin and inject it to the bloodstream. And then it has to bring down the level. Right? When the sugar level goes down, again the pancreas slows down. Yes or no? Right? Diabetic patients typically, right, they say don't eat certain high, right, what is called glycemic, food with high glycemic index.

What is high glycemic index? Simple sugars are dangerous actually. [00:51:00] Why? You take glucose, glucon D, that will immediately get absorbed into the body. Right? Because body is able, able to quickly metabolize. Otherwise, if I take a piece of bread or whatever, it will take some time for me to process that, convert it to the form that my body can use.

If I can directly give that form directly into my body, body doesn't need to metabolize it. It's quick. I can quickly absorb it, right? You understand this regulatory mechanism, right? Now you understand it is a very complicated thing. Food has to go inside, it has to segregate HCL, and it has to dissolve it, digest it, then it goes to the small intestine, large intestine.

So, many thousands of enzymes are there, there is a bacteria that is setting, that is secreting, it needs food and it is helping you, yes or no? Right? And there is kidney filtering blood, liver is also filtering blood, you understand? So much is going on and everything is talking to everything else. So, from a system theory perspective, we look at every organ as one node.

If [00:52:00] I take out one node, what happens? I told you, some nodes are very important. For instance, if that node is, let us say, your stomach, suddenly I remove your stomach, will you die? No. You can actually live for couple of weeks. That is a critical node, but the system can still function for some time. One eye is gone.

Will you die? No. Right? But your kidney is gone. What happens? Right? Big problem. Right? Your liver is gone. Big problem. You understand? Some modes will have a lot of criticality and the interconnection between those nodes, right? So I was talking about multiple nodes, right? And the linkages between those nodes, right?

What is the letter we used? K, right? N and K, right? That is very critical, okay? So, the prime message which I want to give you is, right? Can you wake up Hemachandra? Hemachandra? [00:53:00] Wake up the last guy, right? Hemachandra. Hemachandra. There you can just go around, right? Yeah. I have got my left foot badly injured, that is why I am not able to stand, okay?

So, the point which I am trying to give is that, right? Okay. Complexity in and of itself, right. For students in H 1 5, please listen to me carefully. Very important point. Complexity is not a bad thing. We need complexity to survive. That is why I gave the example of how blood sugar is maintained. Any regulatory mechanism, anything that needs to survive in what is called the dynamic environment, ok.

What is dynamic in nature, right? Ok. What is the dynamic language? Dynamic language, programming language we say, dynamic query. What is a dynamic query? Anything can, anything can be queried, anything under the sun, right? [00:54:00] What is, my algorithm is robust, sir, right? System programmers, they have a metric called robustness.

How robust is my code? Depends on how dynamic is your code. Have you written your code for one particular scenario or your code is malleable enough, flexible enough to address? A multitude of scenarios, right? That is what we call robustness, right? Systems, how robust a system is. Got it? So, that is measured using how complex the body is.

I cannot take a simple code and say, ok, if I, what is your blood sugar? Ok, I cannot sample in, ok, at some random point and say this is your average blood sugar. I cannot do that. I need to take multiple measurement points, right? Ok. Before 4, one measurement. After 4, one measurement. I do it for 4 5 days actually.

That is when I can conclude you are diabetic or not. You understand? I cannot take one spot measurement and say my sugar [00:55:00] level may be 160 now. I just ate and came. After 4 hours, it may go down to 80 90. You understand? If I go measure at 80 90 and say, I am alright. Or if I measure at 160 and say I am diabetic.

Right? It is a complex, even though it, within a band it will be varying. Yes or no? Right? So the point is you need to get data over a period of time to average out. Right? So similarly, right, a system that has lot of complexity and complexity is not complication. Don't use this interchangeably. I am not talking about complication.

Complication we don't want. What is complication? Please go and look at what is called. What is what? Just to put a sandwich on a toaster, right, this fellow would have a, [00:56:00] like, lot of, uh, contraption. That is not complexity, that is complication. Okay. That is something we don't want to do. How am I writing here?

I'm using a stylus. What is called EMR stylus, Electromagnetic Resonance EMR. That is the stylus I'm using to write. So I've got a passive stylus, right, there's a couple of circuitry on my stylus. And the entire writing pad on which I'm writing has got an inductive coil. Two joke lines, where am I keeping?

Am I keeping at the top left? Top right? How is it beautifully able to track? There is a lot of complexity. So just to reiterate, complexity is a good thing. So, but there are two kinds of complexity, bad complexity and good complexity. We want to get rid of the bad complexity. Understand? Fine? So, And systems cybernetics.

Complexity, right? [00:57:00] These three things are interdisciplinary concepts and languages, okay? What we are looking at, right? Complexity as a key property of coherent, dynamic phenomenon. Adaptive, right? The word, there's a one word called adaptive. So right? Adaptive phenomenon. What is adaptive phenomenon and why is, why are we talking about dynamic?

I just gave you the example of a dynamic system. For instance, look at homeostasis. What is homeostasis? Another thing, how do you maintain body temperature? Right? Now, in a star condition room, very cold, what is, what is your body trying to do? It will constrict the blood vessels. Okay? It will try to, your body will try to conserve energy.

Okay? It It will reduce the sweating rate. You are not sweating, why? I don't want sweating. I don't want to further cool my body. Right? So it will do whatever. [00:58:00] You will actually, right? Why would you, you will actually, you will appoint when it is cold, you want to reduce the surface area. If it is, you are sweating, what will you do?

You won't sit like this, right? Yes or no? So, so your body has got a regulatory mechanism. How do you change this? It is actually quite complex. That is what I am trying to say. It is coherent, it is dynamic and it is adaptive. Adaptive means to changing circumstances, external circumstances. When I change an external variable, when I change an external humidity, temperature, right, so on and so forth, my system is able to adapt, right.

And the most social technology problems, right, have good and bad complexity, but let us get rid of bad complexity, ok. Simplification should eliminate bad complexity and it should not eliminate good complexity, ok. So, that is the whole point of, right, complexity, ok. Now, how do we measure complexity, right? I have been talking about some abstract concept, right.

All of you can understand to some level [00:59:00] what is complexity, but if I say so and so on. Okay, how good is he? He is very good, sir. What is very good? What about this guy? Very good. What about this girl? Very good, sir. Who is the best? Right? I need to have some measure. I need to have a, some measurable metric. I need to have something I can measure with, right?

So, how do we measure complexity? So, I am going to introduce a concept, right? Variety, ok. Simple thing, ok. Do not quote me on this. Every year I say students laugh and then but at least you will remember. Variety rice have you seen? What is variety rice? Tamarind rice, coconut rice, tamarind rice. Sometimes in mess you go, there's a variety of rice pots.

Chicken rice pot, bro. Chicken rice, variety of rice pot. Right? Chicken rice does not exist in India. You go to a Punjab, it's not in Rajasthan. What will you get? That fellow will give you so many topics, so many. I don't even know what the names of certain things are. Fried rice is rice which is fried. He gives you a lot of variety.

You [01:00:00] understand the meaning of the word variety? Give it a lot of flavor, okay? So, we are going to use that as a measure of complexity, right? Let me delete this rice. So, we are going to use variety as a measure of complexity, right? Let's look at, right, now, now we are going to measure variety, okay? Look at this, right?

You have got, look at this circle here. How many elements are there? 1, 2, elements are there or 7 nodes, let us call them, right? What is n here? It is actually 2, not 7. Why is it 2? Look at the varieties. There are only 2 varieties sir. What is this? It is a collection of partials. That is what we say. So variety is actually because it is like, it is like I have got sambar rice, sambar rice, sambar rice, tamarind rice.

I have only 2 varieties. I can have as many as I want. Now what happens? Just increasing numbers. Right. Will [01:01:00] not increase variety. You have to increase the. Variety. Diversity. Diversity. In other words, we have to make it more diverse. Right. It is like having rain, I need a rainbow, I need multiple colors, multiple things, right.

Here, here partial similars. What is partial similars? Right? These are all similars. This is similars, this is similars, this is similars. Right? And similarly here. Here, collection of dissimilars. What is dissimilar? I have got different, different things here. Right? I have got multiple cups of different food here.

Right? Ow. Now comes the interesting part, right. Here, I have got a assemblage, what is an assemblage of dissimilar, here we said collection of dissimilar, here we are saying assemblage of dissimilar, there is some coherence and variety you see, n into n minus 1 by 2, it is, is it n c 2 or n p 2, n c 2, n, n, n into n minus 1 by 2, it is combination, right.

So, you actually, you get the formula for combination, why? Every [01:02:00] node is connected to every other node. So, now what happens to your variety? It is 21, essentially. Okay. What happens? So, you understand. From the left to right, I have increasing complexity. In other words, I have increasing variety. Right, and what is the key message here?

Every node has to be different, that is one thing. Every node that I have in my system, if I have to call my system a complex system, not a complicated system, I can have a complicated system here. It is very complicated, right? That is not what I am advocating for. What I am advocating for is complexity, right?

I have, all nodes are dissimilar. And, they also talk to each other. In fact, every node talks to every other node, right. Now, what happens? You get combination, fine. So, what are the two fundamental requisites for a system to be complex? You [01:03:00] need a large number of nodes, n has to be high and those nodes have to be connected to each other.

That is like a basic necessary thing for you to have a complex system. Look at two examples I gave you, right, homeostasis and homozygous. How is your blood sugar regulation? Both mechanisms has got lot of organs that they talk to each other, lot of signaling pathways are there between each other.

Understood? Right? So, now it even more complex, complex, complex. Right? Now, I am not only saying they are connected, there is a direction for connection. This can go this way or this way. Now, it becomes double. Earlier, what was the earlier thing? It was? Right? 21. What does 21 become? It has doubled. It has become 42.

Now this is a permutation. Right? The combination formula has doubled. It has become permutation. Right? Next, I am going to make it I can turn the pathway on or [01:04:00] off, ok, right. Now, look at com, of variety, variety becomes 2 to the power k. You are killing me. It becomes exponentially high, ok. Just to go back, right, we are, what we are discussing?

We are discussing how do we measure complexity, how do we measure complexity? I need variety, ok. That I am using it as a, you guys in the last room, ok. Right? That I am using it as a measure of complexity. Okay? So I need a lot of variety. In other words, I have a lot of elements that are dissimilar. That is the important thing.

Okay? Now I have an assembly of, right, I am calling it assemblage, of this multiple discipline nodes that are there and they talk to each other. And, every node is connected to every other node and the communication channel is both ways and I can turn it on or off. Now, from, right, n into n minus 1 to, right, n into n minus 1 to, now it has become 2 to the [01:05:00] power k, right.

What is the important thing here? k, what did I say, k is? What is the difference between those two diagrams, sir? These two? Yeah. There is no difference? No difference. Why n into n minus 1 is 2 power k? You are a complex human being. We say right, single cellular life form amoeba. It is not complex. It cannot adapt to a change.

You put isopropyl alcohol, it will die. Why? Its cell membrane will rupture. You put isopropyl on your hand, why are you not dying? Have you ever thought of it? You are happily rubbing isopropyl alcohol. All bacteria virus supposedly dies. How come? Because it is, it has a number of antibiotics that you have.

Right, you are wall membrane, right. It is [01:06:00] much more complex, right. It is able to adapt itself to a changing external. But if a pore acid, what will happen? You have not evolved, right. You have not adapted enough, right. May be over thousands of years, if you are exposing a little bit to acid, you will also develop, right.

Look at the have, right. People have done ecological studies, right. Not ecological, sorry, evolutionary studies. And then they have looked at, right, human beings, right, how was their hair. If you go and look at Neanderthal or if you look at, uh, what is the, uh, um, we have Homo sapiens, Homo erectus, what is the other one?

Uh, no, no, there is a Neanderthal, there is another one, I forgot what it is called, right? Some, some, there are parallel intelligent species, okay, they have all extinct. Okay. So if you look at them, you will see a hairy thing, right? What, why? What happened to Nishant? Because they were not wearing all these modern clothes.[01:07:00]

Right. So now we are, we have, actually, we have, even though we are never gone out through science, we have made adaptable clothing. Okay? So we are able to actually naturally, what is the response of that nature? It says, okay, this guy is, is able to actually model it. Let me reduce that right? As you actually, if you see right, you go back.

If you look at people living in. I do Europeans have these noses, Roman noses? Why do they have these long noses? This is not a racist remark I am making. Think about it. Some students have misquoted me. That is why I am giving a disclaimer. Look at Africans. Why do they have short noses? Africa is a hot continent.

I do not have to heat the airway. Ok, the passage. You go to Europe. Most of it is, there will be snowing all the time. What happens? And it is at minus 15 degree 20. I have to take it if it goes to lungs, it is a bad thing. So the passage way has to be longer. That is why you get long lungs. [01:08:00] Ok. People have reasoned.

This is not, I do not know if it is character. This is something anthropologist, right, biologist, they sit and then they have, they theorize and say, oh, this is one possible likelihood. Right? Similarly goes with skin complex. Right? Right? You understand? So It is a question of, the reason why I am bringing this up is, right, if you want a very complex system, not a complicated system, complicated, I just spoke about Rupert Goldberg machine, okay.

If it is corrected, maybe I will quickly show you a video of, uh, Rupert Goldberg's machine. Look at Honda R, right, that is what, Honda R, you want me to play that? Yes, sir. Everybody is saying yes. I don't know, right? If this is corrected, possibly I should be able to play. It's not corrected. Unfortunately,[01:09:00]

we as a

let continue another five minutes. We'll take a break, right? So this is that, right? Let me go forward, guys. Listen, I'm going to give you a formal definition for.

Emergent. You remember this term? Emergent behavior. What is emergent behavior? Right? We looked at the example of a Porsche car, right? A Porsche. Porsche. Porsche. Porsche. Porsche. This was probably a crore, this was probably 10 lakhs, okay, if it is one tenth the price. What if I take a coach and if I drive in Kandigarh road?

How will you feel? It will be a very bumpy [01:10:00] ride, right? It will be a very bumpy ride. And the car can go really at 200 kilometers per hour. Can you drive here maybe 10? That is all you can do. There will be a cow that will be coming in the There is potholes. There is a dog on the street. You cannot do much, right?

Now the point is If I have top of the class car and if I put it in a context where it is not suited for, what is the emergent behavior? Experience is not so good sir. But, I take a swift, I go to Germany, they have got this high speed track. How would you feel? So, as many students are saying, I feel good sir, amazing.

Now, same swift I put it in Kandigay room, what happens? Swift in Kandigay exists only. Right. So. What this we call emergent behavior. It's the same car. I am putting it in different context. So that has got a consequence, right? Many things are coming together. [01:11:00] It is creating a emerging behavior, an emergent behavior product.

Got it. That is a very important thing. Okay, so, so what is the system? So, we are saying a system is a pattern, that is coherent. What is the meaning of the word coherent? Coherency means what? You are, you might have heard this word in laser. Yes. Coherent. What is the, you have a coherent beam, yes or no? What is coherent?

All the Constant phase. Vibration of the molecules, they are in perfect phase, right? Time, they are in perfect phase, right? Perfect sync. So, that is what we call coherency. Coherency. Okay. English meaning of the word coherent. The theme is not coherent. Highly incoherent. This guy is doing something, this guy is doing something else.

There is no proper channelization. Nobody is, we are not working together as a team. Right? Highly chaotic. Okay. That is our [01:12:00] typical, these lights, right? That is why it does not go far. A laser beam can go far. How come? Because it is a coherent beam. Similarly, right, a pattern that is coherent and has got emergent properties.

What is pattern? Portia car with a high and good fuel, with a very good tyre, on a very good road, right? This is what I mean, okay? Think about this, right? That is what we call as an emergent property, okay? That is greater than the sum of the parts. You understand? Now the Portia car is a system. Constituent is awaited.

What are you going to register? Content. What are you going to register? We welcomed this discussion. Okay See, n has actually [01:13:00] disappeared. Why? Nobody asked me this question. See, in every other thing. Okay, here we have n. Next place we have r. Right? But here we are saying, it is 2 to the power k. Right? No, what, the reason being?

Okay, reason being relationships, right? The connections are more important. That is what I am trying to say. The connections are very profound. It has got a profound impact, right? So, everybody understands now what a system is? What is a system? Formal definition is it is a pattern that is coherent. And has got emergent properties that is greater than the sum of the parts.

System itself has got multiple components, sir. But these components interact with each other. I have got a Porsche engine, right? I have got this petrol, it is burning like this. I have got this engine oil, this tyre. All [01:14:00] this put together is what gives you the driving experience. It is not just best engine, best tyre, best fuel.

It is not that. Think about the coding, coding language. Which one would you prefer if I give you basic, ask you to, if I ask you to program in Fortran and then I say I give you a 8085 microcontroller, would you be happy doing that? Have you ever programmed a 8085? I don't know if you have it in your syllabus.

Do you? Right? Would you prefer that, right? We have got one electrical student here, right? Let me ask him. Would you prefer that or do you write, do you like writing in Python? Python. Uh, he's saying, uh, Sir, I like writing code in Python scripting. Why? It is the same code, right? Same logic, right? It is the way you write, right?

The way you interact with the system, right? Chart decides the emergent behavior. Right, if you have to go to Fortran, guys? I have to learn specific syntax. Debugging is painful, right? It uses a dated syntax, right? Compile has to do, compile the code, right? [01:15:00] A lot of coding has to do. Python, foot, click on arrow, done.

So easy, right? So that is what I call as an emergent behavior. Now, it is not the parts that matter. It is not the relationship that matter. It is the way these parts interact with each other. Right? That dictates or that decides how I feel. Right? How I experience the system. Right? Last week, uh, another example I gave you.

Having, right, biriyani in some small restaurant here in Kandy or you go, going to Kajkoram. Kajkoram. Same, same. Who is the owner of Kajkoram? What is the design? System we said, ok. Sir, it is a pattern that is coherent and has got emergent behavior that is greater than some of the parts, right. So, this is the system definition.

What is design? Design is also a pattern. But it is distinctive, yet contextual, engaging, and empathetic, okay, let me go one by one. What is distinctive? Distinctive means what? [01:16:00] Distinction. This guy has got a distinction in so and so, of course, or this guy's very distinct characteristics, this guy's got a very distinct characteristic.

Unique. Right? What does it mean? Right? It's, in a way it is different. And it is contextual. What is contextual? We said design is contextual. Why? I'll give you an example. Something which you can all agree on. All of you know about IKEA furniture? Badresh went, no? You went to Chennai IKEA. Go take a look at IKEA's, okay, sofa.

That's it. This is IKEA sofa. There are four legs, two arms, right? White color. Guys, we'll take a break. I'll come back. [01:17:00] Let's take a break. Let's take a 10 minute break. What the hell is wrong with you, bro? I'm coming, I'm coming. I'm coming, I'm coming. Hey, manager. You look really good today. Students in 1, H15, you can take a break.

Come back in 10 minutes.

That's what she said.[01:18:00]

I can't see you. I'm sitting right here. Where are you sitting? [01:19:00] I'm sitting right here. Make some noise.

You know, I don't know how to spell it. I don't know how to spell it. Billion and awareness week. Billion and awareness week.

I have to turn off the AC. It's like a [01:20:00] hot stove. We have to suffer. I can't find any gas.

It's a proper effort. We kids get A, B, C, D. What is the temperature there?

21. 5 There's a temperature dropout. There's a mechanical, there's a hot air condition. But finally it's not going to happen. What do [01:21:00] you feel is the time? It's coming.

BP. Third test with BP. BP. Do you want to meet? What are you doing here? Can you get some water? Yeah. You get? Do you have water there? No, I don't. You can get it inside. I'll get it inside. I'll get it inside. I'll get [01:22:00] it inside. No, I won't.

CR is good. Bro, we don't have anything with CR. No, it's dual degree CR. It's definite, dual degree. CR has no limit. You will go back after 3 years. I have been here for a year. I was in a back blocking training.[01:23:00]

I just feel it.

Take it. It's really soft. No. I don't know. They were just a guy that looks like him. I don't know. They weren't with me. Narsimhan Venkatesh Sujana Sujana Atma Kitab That's it. That'll take you there. Mohat log bahar hai bhai.[01:24:00]

Uh, soil is not well tied, rain is not coming, right? But if you keep probing, right? Somewhere regarding data, which is what you are encountering.

How can you leverage your knowledge with what is, it's not an easy process, but you actually, you have to actually have some insight and spend some time with the not one many of. You understand? Get some idea? I'm just rephrasing your thinking. I've not even got into what you're doing. But whatever you do, right, first cut down that barrier.

It should [01:25:00] be super easy. And if you're talking about some data collection, some level of automation is fine. Watch that. Even, it can be semi automated also. You can not only go ask That's okay. Instead of putting a camera, that's a thing that's possible. And that's how you're going to find instruments on the land.

You can do that. Right? So mobile phone is your point of interest. That's the connection point of the phone. That is going to interact with something out there. Right? So what are the options? Okay, he's doing somewhere. Again, there are a lot of unified apps, or over apps, they call it. Look at that. Where do you post your What are all the different Solutions are there, currency.

Where do those solutions can be improved or neutrally paid, which you can maybe address. That should be the intervention. Get the idea? So, Leave [01:26:00] technology aside for a second and ask the question, Okay, what are your top 10 problems? And as a CS guy, I am worried about data, mostly. If at all, data or something else or building an interface for you that is more user friendly for you.

Right? And who are all the stakeholders? Is it just the farmer or is it someone else also? Is it the supply chain? You can also look at the supply chain. This produce goes to some warehouse, government warehouse or some privately used warehouse from the foreign countries. I buy from Amazon. Amazon Fresh.

Makka Tomatoes is given. Yoka, see, I order from center of Chennai, Anna Nagar. I'm ordering. I go to the local market, terrible tomatoes. Same home, I'm ordering from Big Basket, terrible tomatoes. Amazon Fresh, what is this guy doing? The other two hours he's bringing, he's coming from somewhere close by only.

How come this guy is able to source such fucked up products? Same price. Right? Which means his supply chain, something he has done, I don't know what he's doing. [01:27:00] Same price I pay, I'm sitting at home, Pressing a few buttons, I'm getting the best tomato paste. Big basket used to be good, it has gone bad. But if I physically walk and go to the local market, I'm not able to get it.

But, if I take the train, go to Coimbatore, it's a hub, Chennai's hub. Go there, I'll get good produce, for half the price of Amazon. But I cannot travel every day. Weekends I used to go by. You understand, this supply chain, how is Amazon doing so well, you have to go study. Now, some poor farmer is able to make good produce.

Best quality sir, but sits in my warehouse for two days sir. If it's a transportation problem, there is not much you can do. But if it's a question of linking, again these are all age old 20 year old problems, not new. Something for you to just look at it as an academic exercise. What does it take? Right?

Not, that's why I have been insisting. You are not just a programmer, you have to really understand. Because, future computer scientists will belong to those who can actually understand the problem and solve it. You are a problem solver, not a [01:28:00] coder. Coding, Coding, Cognitive Dealing, understood? Now, if you take a, A little bit.

That's the insight you have. Go back, then you can. Done. Do a bit more. Just follow him. Relax. So you come, we'll go talk. Alright. Okay. It's fine. The problem set is fine. It's fine. It is India specific. It is not that. It's a people's problem. That's okay. Problem set by this guy. Sir, problem is good. As you know, we were discussing yesterday what kind of problems are facing from morning till evening, sir.

Okay. So, while we were talking about it, we discovered that while traveling in the bus, [01:29:00] getting at the bus stop is one of them. Getting, getting, getting out of the current stop. Getting down. So for example. What's the stop? At the right stop, like, I'm in Chennai, I'm in Tamil, I know where to get down. But other people, language people, maybe they will say, next stop is this thing.

So for example, in our team, there is Parth, there is Aditya, there is Harith. All, all, all, all three of them are not from Chennai. But then they, they, they kind of refuse to take the bus. You can't run back, I'll get you a problem. So what I want you to do. So, uh, what we thought was to find out the existing form.

Really metro, arguably not central. Exactly metro. That's exactly what we thought. That's exactly what we thought. No, no. Don't reproduce the solution. Ah, Bobby missed. But exactly that's the thing. Metro, it's written. It's written in Tamil and all. But what if people don't know Tamil, Hindi or English? No, no, no.

We can make an announcement. Okay. We can announcement, we can do it. We can't do it pretty loud. So, what we thought is, we can [01:30:00] probably have a, a place. A place. A place. A place. I am a tourist. I don't have your number in system. You want to get out of your station, it will be, that particular station is associated with the number.

What are the specifics? Right, sorry, not the specifics. The concepts will know. All of these points will know. But, what I want you to do is, what are all the existing Extrovert are from here. Extrovert, right. There's a, uh, display with the lights. It will also let you know, like That, that, that, that. And which is the cheapest interface?

Like, bus ticket is 4 rupees, 5 rupees, right? You can't have, like, you can't even, uh, IOT connectivity, right? Even ride, right? Putting GPS, right? Even some buses still do it, right? There is an app, you can track the bus. That's why if I have that, that works. You know what, uh, what, what we faced was, like, pointed out that, uh, having [01:31:00] that app constantly on your phone and looking at it constantly, that's what happened.

What is your interpretation of that? What is your point of view on that? Sir, there is no such thing. Even inside the first, there is some media where you can afford independent of language, independent of That's what I'm saying. Independent of language and questions, you know, this is where I have to get help from.

So that's what we want. Sir, do some, uh, literature on this. Give it a try. 663. 4. 663. 4. 663. 4. 663. 4. 663. 4. But, uh, I need to have a, uh, depth of what, so we will, we will, we will do on this side. I'm going to be 10 minutes ago. Guys, get inside. No, no, no, no. Get inside. Get inside. Get [01:32:00] inside. Get inside.

Turn it off. I'll ask him to turn it off.

Yeah, yeah. I'm just asking. Good. I'm just asking. Yeah, good. Yeah. Then you [01:33:00] write your number. Yeah. I thought he was out. What? I'm not going to show you. This is Mamba's apartment. There's a playground nearby. There's a playground nearby. It looks like a park. There's a yellow coloured building. Yellow coloured building.

Hey! No message from my wife.[01:34:00]

So guys, settle down. So if you pay well, I'll let you go a bit early. Okay.

I was talking about.

So, I was discussing, are we audible in the last room? Right, so I was talking about IKEA sofa. What is, what is so special about IKEA sofa? Nothing special, it [01:35:00] is, minimalistic. What is minimalistic? No specific design, sir. It is plain. Just like this chair, nothing of interest. So IKEA actually, worldwide, right?

As simple as possible. What is going on there? Right? So IKEA, if you look at worldwide, right, IKEA has been a big success. What is their success story? Right? Their business model, right? So, I, I, I, I, I, I, I, I, I, I, I, I, I have been at home since [01:36:00] morning. He has to make all the pieces, assemble it together, then paint it, ok.

So, they are thinking for processes, ok. Labor is one big chunk of the furniture cost, right. What can we do to reduce it? Let us get rid of the carpenter. Is it even possible? This is the thought process, right. What is the most expensive part of making a furniture? Wood itself, right. The material itself, processing and a big chunk of it is the labor.

Ok. The cost it takes to process the furniture. So, their thought process was, let us get rid, guys in the last row, right, let us get rid of this labour, right, let us get rid of this, right. And who is going to make it? If the carpenter is not going to make it, who is going to make it, right? Which means I am going to have automated machines that will make the furniture, which means my design has to be simple.

You understand? It is actually ulta. They are projecting a lifestyle in terms of minimalism [01:37:00] way. If you have to make complex geometry, see a simple square is easier, right? Is this easy or like a fancy flower petal, right? Is this easy to make? Which is easy to make? Right? Obviously, a square or a cube is easy.

So, it is easily I can automate it. So, what do I do? They are saying they are propagating this. We are done. Now what is our question? How to identify from 20 percent to 80 percent of employees? 90 percent of employees say, yeah, yeah, yeah, yeah, yeah, yeah, yeah, yeah, yeah, yeah, yeah, yeah, Where people speak different languages and they have no idea how assemble the furniture.

So what these people do, they make nice illustrations and they come up with beautiful designs where it needs just a screwdriver, one screwdriver, [01:38:00] right? We just turn a screw. If you can turn a screw. Yeah. That's all I need. Anybody can assemble my furniture. Right. That is why they come up with this sort of a minimalistic design.

This is a Scandinavian design, works for Europe. Works for USA. They put up a shop in Hyderabad. Anyone from Hyderabad? Have you visited IKEA showroom there? Is it crowded? Anybody from Bangalore? Have you been to the IKEA showroom in Bangalore? Is it crowded there? Why? Massive space. In Bangalore, recently I checked, it is huge, humongous, right?

That is because the showroom in US, they have put it. It is not working for them. Why? What is the first thing we expect of a furniture? I will buy, my son will use it, uh, his daughter will use it. I want it for five generations. That is the typical Indian mentality. That is Indian context. That is Indian context.

I want a furniture that I can keep repainting and [01:39:00] use it for 100 years. That is my expectation. A typical Swedish guy when he is buying, right, when the fellow is buying, what is his expectation? $10. Can I get a chap? Oh, I can get fine. Maybe if it works for two years, I'm happy. I'll throw away and get a new one.

That is his mentality for us. If I get a chap, I want my grandson to use it or my granddaughter to use it. That is my thinking, right? So Indian context is different from European context, right? So that is why design is contextual. Does it make sense? So, it is a pattern. It is distinct, right? Indian art is distinct, European art is distinct, right?

American art is distinct. And it is contextual. It is engaging, right? You understand the meaning of the word engage, right? And it is empathetic. It is empathetic to the local context. What is that you want? Oh, you want a long lasting furniture. I will give you that. But it will be heavy. I do not mind heavy.

You need 5, 6 people to lift it. That is all fine. It is okay. Right, or you [01:40:00] want something or you are a student, European student, you want to carry a furniture and a box, fine, that is embedding. Right, I will give you that, I will give you what you want, right. So, now you understand the word of, meaning of the word design.

Here I am using it as a noun, not as a verb, right, not the process of design, but design, what is design, what is it all about, right. So, so far we have seen a system and we have seen design. Now, what is innovation? Innovation is also we say it is a pattern. And I said, I'm attractive. It is dynamic and it's beautiful.

Right? Who was that? Okay, you understand? So, what is innovation all about? What is innovation? Fundamental question. Keeping this definition aside, right? Do not worry about this definition, right? Do not worry about this definition. Think about that, uh, in your own intuition, right? What is that innovation means?

Again, if I ask [01:41:00] new, sir, something new, brand new, something that is unique. Something it has not been done before. Something that is novel. These are the things that will come up. But if you have to achieve that, what is it you need? You need actually a pattern that becomes an attractor means what? People who normally don't talk, when they talk.

A biologist and a physicist, if they talk. A biologist and an engineer, if they talk. Right? You will have new ideas. This fellow will say, you know this fish? It can change colour. Chalicek Kemal is saying, yeah, I know pigment I can use this to change color. And then he may say I do not know anything about biology or this thing, ok.

I know it can change color, I can make a light bulb, now give me the idea. You understand now it becomes a source of attraction. Silicon valley, all of you have heard right, what is silicon valley? What is silicon? Semiconductor. I see. [01:42:00] Right. Why do they name it Silicon Valley? Silicon Ba. Mood Silicon. India's Silicon Valley is

What do they say? Why do bad mood becomes baud is an attractor for talent in India, right? Some of the best mind goes to Bangal. First of all, it is school there. Like my my is nice. Technically speaking, right? Geographically speaking, right? And there is an ecosystem. What is the ecosystem they have? Sir, I want to make a start up, sir.

I have an idea. Okay. What do you want? I need land, sir, given. I need electricity. Okay. I need water. What is the most important thing? Any government can give you these three. What is that most government will struggle to give you? Investment also they can give you. Workforce. I am going to give you a trained workforce.

Why is Warangadam, why do you find lot of factories here in Warangadam? Why is IT corridor, right? Government, like why design, right? This was all literally fields. I know [01:43:00] I All the YMR, right, some of the places used to be fields where they do farming 25 years back. In my lifetime I have seen that entire road transformed.

It is by design. Government wanted to put up all these buildings there and invite MNCs and then say put up your shop here, right, give employability. What is that your, uh, all your MNCs they are asking? Right. Right. Accenture, right, your, uh, DBS, all the banking sectors, all the IT sectors, what is it they are asking you?

I need qualified skilled labour. Can you do that? Put all the colleges there. Put all the. So, I have colleges, schools here. They will train and give you manpower. You take, use them. Right. That creates a attractor of talent pool. Understood? Right. So, that is what innovation is all about. It is dynamic. Right.

Constantly changes, why? Why is it dynamic? Right? Think about the evolution of cell phone, right? [01:44:00] It used to be a wired landline phone, right? Anything that was wired became wireless. Phones used to be wired, they become wireless. Cable television, which used to be wired, become wireless. Internet has become actually wired, wired connection is better, right?

It is actually gone oolta, if you actually see. Anything that was wireless, tv, right? I used to have an antenna. You have cable operator sitting in a cable I can add, right? You say you take one wire, you get telephone, you get internet, you get your tv, right? So that became wired, right? So there is a transformation.

So what is standard today? The facto standard? What you take for granted saying this is how everything operates. That is why it is dynamic and it is constantly evolving and it grows. This is fine, right? So quickly system, design, innovation. It is all pattern [01:45:00] and the pattern depending on what the pattern is either it becomes a system or a design or innovation, right?

So patterns differ in terms of degree of complexity, right? It is a function of, right? you The number of elements that are there, right, the connection and the content, right. So, very important slide, right. So, the three concepts, right, that deal with the different levels of complexity, ok. Let me start at the bottom.

Let us go bottom, right. Let us start with low complexity. What is low complexity? I turn on the light bulb, it glows. Simple, simple idea, ok. There is a pause. And there is an effect. Okay. I spend 2 hours for writing an assignment. What will you come and ask me? Sir, you have only given me 2 out of 5. I will not agree with this.

I spent 5 hours. Entire Sunday sir, right, you are yet to submit your assignments. I will get all these questions. Entire Sunday I [01:46:00] spent, you only gave me 2 out of 5. I 2 marks. This is not fair. Why? Because you are using what is called input based recognition. Your thinking pattern is I spend time, give me marks.

Rather what I am asking is, I am going to measure you based on your outcome. What have you done? I do not know if you spent 1 hour or if you spent 10 hours, right? That is invisible. I am not seeing that. What am I, what am I seeing? I am looking at your outcome. If you simply say strong cause effect, I did this and this happens.

If I apply this force, this moves, right? So, at a lower level, at a component level, that is what we say. At a component level, what is happening? Right? You do this, this happens. You take a p n junction, you send in electricity, right? You will get this output. You make a transistor out of it. Simple component, right?

So, I will just call this [01:47:00] one 1, 2, 3 as I was explaining earlier. Number 1, 3, 4, 5, 6 as I was explaining earlier, 1, 2, 3, 4, 5, 6, 8, 13, 14, 15, 16, 17 and 19. You go to subsystem level, you look at the system level, you go to the organization level, highest level in the society level, look at the complexity. It is very complex.

Why? Because what has happened is, instead of worrying about the cause effect, we are now measuring everything based on count up. We are not worried about loss effect at all. For example, if NIR of ranking we have, NIR Okay. Any area of ranking? Our institute, I don't know, one 10. What [01:48:00] is our current ranking?

We have a brand actually right under 2, 1 50. Okay. Let's say one 10. I don't know. Right? This is one measure. Okay. If the ministry calls and asks me, why, why are you at one 10? Why is you, why, why are you not doing better? If I go tell them, sir? No, sir. I spend, uh, 10 hours a week teaching, sir, I do this, but this is this.

How many students came, how many of them graduated, how many of you are able to employ? Right? This is the measure they are simply looking at outcome. You are sending out 2000 students. That's it. That's all they'll ask. What is the discipline? Done. Sir, we are having a problem with the hostel, ministry does not want to hear this.

So, what they are looking at is, because they do not care about [01:49:00] the time at all, what they look for is the visible outcome, what is called the visible, something I can measure. What is the visible outcome? Visible outcome is one simple measure is how did we measure complexity, variety, how do we measure, uh, how good is this store?

One measure is, look at the . Not the best measure, but it is a measure not right. Look at one daily two or three, I don't know. I don't know the exact numbers, right? So you go, you go by that. So, as you go up at the organization level, in other words, if you are a fresher, if you go join any company, if you work for 10 hours a day, you are going to be rewarded based on how much time you spent initially.

So, you are at the low complexity level, but if you continue to do that, you will never get promoted, you will be either sitting at the lower level. As you go higher up, what is expected of you as a person. Right. You are measured based on [01:50:00] outcome based, right? Okay. Now my thinking has to be, I have to develop this product.

What does it take to build this product? Okay, I need 10 people. I need 10 engineers, three programmers, three electrical guys, right? Four manufacturing engineers, right? That is what I'm looking at. How do I manage them, right? So that is what design thinking and systems thinking is all about. So, complex, complex complexity theory, right?

Talks about all this, right? So, when you have low complexity, what did I tell you? The interactions are few. When you have high complexity, 2 power k, remember, right? So, interactions are going to be very high. Right? This slide clear? Right? Let me clear this, right? So, quickly recapping this slide, at a component level, it is highly engineering discipline based, right?

Strong cost effect and it is input based. I spend this much time, sir. I put this much effort. As you go higher up. In the complexity ladder, what you get is weak cause effect, but output [01:51:00] based recognition becomes takes center stage. It is very important, right. What is that? You have, that is the question I will ask.

I do not care whether you spend 1 week, 1 week, 10 days, it does not matter for me, right. So, look at this, right. So, if you look at this, what are the different aspects, right? So, last week, right, hopefully, right, let me recap. We looked at, well. Function, right? Multiple things, right? We looked at the examples of all App Medium, remember all that, right?

So this is another way to look at it, right? So yeah, what is, what is function? What is its purpose, right?

What does it do? What is it meant for? What is behavior? Behavior? What is behavior quality? And.

For instance, you are in your classroom, okay, you know I will scold you, I will reduce marks, you are quiet, [01:52:00] okay. If I leave, how will your behavior be? I am not here. Completely opposite, right? So, that is something like that. Structure, what is structure? Physical body. How are multiple nodes connected to each other?

That constitutes, right? Process. The process of, it is a verb, right? How do you make something? If I talk about writing a piece of code, writing the code, right, how do you write it? If I talk about building an automobile, how do you make it? If I am talking about singing a song, the process of you, you composing and singing, actually the act of singing, that is the process, right?

So, if you quickly look at this, right. So, it takes a lot of time for me to go through each and everything, right. So, if you look at, right, what are the aspects that specifically we expect? Look at the social aspect, right. So, typically, right, if you look at, look at all this, right. So, I am not going to go touch each and everything, right.

So, [01:53:00] you can do, Design itself, right? It can be multiple verticals, what we call verticals, right? You can have customer focused, right? Your product can be customer focused, right? Or the design can take life lifecycle perspective. What is lifecycle perspective all and steps from its inception to obsolescence of the product, right?

It goes through a life cycle. Right. So, there are various factors that are involved, right. Look at all the different techniques and tools that I will use, right. Biomimicry already we spoke. Ethnography you already know from sociology, right. You can do, uh, SNAC and all, I will teach ISM, just for now, I will cover in the upcoming slides, right.

You start with the concept thing, right. And GRIS, right, Minimal Viable Product, right. These, these are all, right, this will go at, uh, at a much higher level, right. Stage 1, 2, 3, 4, I said, right? This is at a, uh, this will cover in the later semester. Right? [01:54:00] So you understand? So it goes like that. Okay. And, uh, presentation, I don't know who he is.

Yes? Right? Okay. Now, this word I keep using over and over again. What is it? Emergent whole. What is emergent whole? That is a lot of components, elements, that interact in That gives out the emergent behavior, right. So, we look at emergent whole and parts, right. Anything is a whole which is operational is quasi independent of its environment means what?

Quasi means what? In small steps or not completely independent, right, there is some relationship, but it is little bit disconnected, right. For example, right, an apple, right, an animal, right, so on and so forth. If you look at an apple at a broad level, right, Apple is composed of multiple molecules, that molecule in turn is composed of atoms, right?

What you see as an apple is [01:55:00] a constitution of multiple elements, how they are connected, right? How it smells, how it tastes, how it feels, all that, right? So that is the point, right? So, so you can take, right, parts are the immediate basic factors into which holes can be analyzed. What is it made of? You take atoms, assemble atoms to molecules, right?

Now the question is, right, what do you call a subsystem, right? So broadly, right, all these sentences, what the entire, this entire sentence, right, the second sentence, what it says is this, right? Depends on your magnification level. What is magnification level? Sir, what is a subsystem and what is the composition, okay?

The question is, it depends on my definition. Okay? If I take a system, this classroom as a system, I can treat every student as a

at a classroom level. If I take you as a system, [01:56:00] then I can take your organ, SA subsystem, you understand it. It all depends on what is that my intent? What is it I'm doing at a macroscopic level? If I am studying the interaction between students in a classroom, I don't care about your digestive process.

About the interaction within you, I am doing a approximation in entire you I am considering as a node. If I am taking you as a system, then you are subsystems, different organs. Let me zoom in further. If I take your organ, then that organ becomes a system. If I take your lung, again alveoli, right, I can go down further, right.

So, that is what this says, right. Rock analyzing into parts and crystals and apple into such, right, skin, flesh, seeds, so on and so forth, right. So, subparts are the second levels of analysis, right. Crystals into molecules, apple flesh into cells, so on and so forth, right. The fundamental question you have to ask is, sir, what is my system?

Once you define that, then that defines what is your subsystem, then parts [01:57:00] component level you can go, right? Right. So holes can be parts of still larger holes. That is the point I'm trying to take holes means what if I take the entire classroom as one node? So classroom itself is a hole. There are multiple classrooms.

If you look at, at the institute level, then the classroom becomes a single note, right? And sub parts can be analyzed into sub, sub parts, right? Rocks into parts of mountains, apples into part of a three system, so on and so forth. So, the entire slide talks about what is the level to which you are zooming in.

Are you taking a bird's eye view? Okay, bird's eye view is fine sir, right, it is like zooming into Google maps. I can look at Chennai as one node, if I zoom in further, there are multiple areas in Chennai, I can zoom in further, right, so that is the thing I am looking at, right. System and complexity differ in the way they view parts and holes, right.

In complexity emergent properties, wherein systems holes are treated as a level, ok. That is the key thing to remember, ok. Very important thing, [01:58:00] right. So, there are different types of relationships, right. So, we represent, right, the symbol K to represent relations, right. Transitive. What is transitive?

Relations of two parts to a middle part, right? A is linked to B, is linked to C, okay? Transitive means? Relation of A to B is through C. So B, it uses it as a transitive. Okay. Symmetry, where interchange of parts does not involve any change in relation. Okay. Self explanatory. Additional types of relation can be combination of these two.

Okay. Correlation, what is correlation? Right? A relation can, a relation between two series such that for every part in one series, there is a corresponding part in another series. All of you know, set theory A, B, C, D, right? [01:59:00] So, you have a map from one set to another set, right? That we call it a correlation.

Dependency. Relation in which existence of one part is conditioned by some other thing, right? Limb of an animal is dependent upon its circulatory system. What do I mean by that? For one thing to happen, something else has to happen, right? There is, there is dependency, right? There is a parent child relationship.

What is parent child relationship? For the child to exist, parent has to be there, right? Okay. Okay. So. So, I will, I will talk about all this, right, in the upcoming classes in a larger thing. I will summarize the whole slide for you, right. So, rules of interaction between parts, local, besides emergence, right of ease, ok.

So, let me explain this, ok. Have you seen these bird swarms, where you have lot of birds? When you look at it, it will look as though it is following a nice wave pattern, but if you go actually talk to a bird, ok, that fellow will [02:00:00] say, no, I am not making any pattern. I am simply keeping my distance. So, this is what is called as swarm.

In computer, right, in navigation, people specifically work in a specialty of CS, computer science. It is called navigation. What is navigation? I want to go from a starting point, origin to a goal, right, and there are lot of obstacles on the way. You have to navigate this. And then go to my goal, depending on, right?

My objective has to be reduce time. Guys. I see someone talking, sit, Eric, don't slump, right? So, right. So I have to go from a starting point to a goal. I have to navigate a set of obstacles. My objective has to be reduce time, reduce distance, reduce energy. It can be anything, right? If I have to do that. The [02:01:00] point is, here I have a bird's eye view, I can tell you our goal is here, but for the, what is called the agent, right, the one which is actually doing the navigation, what it will do, it will go look here, oh there is an obstacle here, let me avoid it, it will come here, oh there is an obstacle here, let me avoid it, and it might end up even coming back to the starting point.

I do not want that, right, I want it to intelligently keep progressing. Now, this is one. Let us say I have like four or five of such agents going, right? What will happen? So, imagine a school of fish that are going, right, 10 15 fish that are swimming together, right. You have seen all this flight formation, right, during Independence Day, they do all this in Delhi, they do this.

So, every pilot, right, what that fellow will do is, who is in front of me, who is to my side? Ok. Often what will happen is, right, if you look at these crashes, right, the guy, right, if they are flying a B 4 fish, [02:02:00] ok. There is a plane here, there is another plane here, right? They follow all these patterns, right?

So this guy is only worried about these two guys. This guy is only worried about this guy. This guy doesn't have to worry about anything. He is the only leading. Okay? So others will follow. If this guy crashes, everybody will crash. This is a well documented problem. Why? It's stupid, right? Your leader is crashing.

You are seeing him crash. Okay. Why would you also crash? You are going to die. That is the ultimate thing, right? Often, right, during one exercise, I think it is in France or somewhere, right, couple of decades ago, the lead pilot crashed actually. Everybody followed also subsequently crashed, because they are trained to follow the guy right next to them.

Why? When you are flying in such close formation, you cannot doubt the pilot. You have to think about your partner. Your neighbor, immediate neighbor you cannot question. Is he doing the right thing? You have to accept he is doing the right thing. Everyone else is following the leader. [02:03:00] So, if leader makes a mistake, everybody will follow.

You understand? So, there is a global emergence of coordination. Even though at an individual level, okay, I as a participant, right, I am not worried about the whole thing. There is no centrally orchestrated, there is no one conductor sitting, ah, you fly here, ah, you move, flight number 4, move to the left, nobody is saying that.

But they are able to nicely follow a pattern, helicopter pattern, how are they able to do that, right? First guy takes the lead, he says, I am going to follow, he will have a set trajectory, he will follow. Everyone else will follow their neighbor. And if they are, first guy crashes, next guy is trained to follow him, even if to crash, that is the level of sync they have.

So, look at this, which is highlighted in red. Rules of interaction between parts, local, besides, emergence, flight of these, what it means is, they do not crash into each other, but when you look at it as a whole, you are actually able to see a big pattern, right. So, that is what is [02:04:00] the beauty of, right, having a localized control will lead to a centralized control, even though centrally there is nobody controlling, right.

This is what is called in swarm. Swarms, they do a lot of study in robotics, right? Take these principles, actually look at shoals of fish, look at all these flight of bees, right? And other birds, right? And then use that, right, for actually writing algorithms to actually basically do this path planning. You understand, right?

It is a very interesting thing, similar to the analogy, right? I, I was talking about having a one scientific model that describes two states, right? This is one such example, right? And, let me go back, right? So, this definitely I, I, I will visit in a larger, uh, detail in upcoming classes. For now, let me quickly give you definitions, right?

Boundary, environment, closed and open system. What is a, what is What is a system? [02:05:00] What is a system? I just gave you a definition. It is a pattern that is coherent and has got emergent behavior. Do not forget that, right? There are elements that interact, that work in a coordinated, coherent fashion whose emergent behavior is greater than some of the parts, right?

That is the example I gave you, right? That is the definition I gave you, not the example, right? So, that is a system, ok. Consider this as a system, right. There are multiple elements, right, and they are talking to each other, right, a lot of linkages. Now, what is the open system? You have a system, right. You got these nodes, right.

They all talk to each other. Now, when I have a boundary, boundary can be physical or it can be virtual. Please understand. What is the boundary of this classroom? These walls. Right? What decides whether this is an open system or a closed system? I can [02:06:00] control the boundary by opening or closing the door.

Right? So, is the system open? Now, it is an open system. Air conditioning is leaking out. Right? If I close it, if I close the boundary, it becomes a closed system. Now, boundary can limit flow, flow of matter, flow of energy or flow of information. What about a cyber physical system? What about a computer system?

So, what is your boundary? Uh, your firewall is your boundary, right? It is a virtual wall. Your firewall basically constitutes the boundary of your virtual system, right? Then, if there is an exchange of matter, energy or information, right, it is an open system. If there is an exchange of nothing, then it is a closed system, right?

What is the environment? What that surrounds the system typically? So, look at the formal definition. Boundary can allow or prohibit exchange of matter, energy, information [02:07:00] with the environment. What is environment? Anything that is outside becomes my environment, right. So, now the problem is this can also lead to some, uh, weird positions, right.

This can lead to some group mentality. It is like what is sacred and what is not sacred. I am in a first world country. You are in a third world country. Right? I, I, I am better than you. Yes or no? They have a boundary. Right? So it can lead to, right? What is inside the boundary is sacred, what is outside is profane, right?

It can also lead to such a thing. Okay. So we can take a systematic view of physical sciences, chemical sciences, right? If you see, right, you see this, right? Pretty much, right? This is again analogous. Lot of analogy we can derive, right? Biological sciences, right? Uh, You can go in great detail. Just for example, I have put it, right.

So, what is deterministic? Anything [02:08:00] I can say with certainty, I can calculate with a mathematical formula, that becomes a deterministic thing. Human nature is a deterministic? No, no. It is highly non deterministic, right. So, So another ten minutes I'll wrap up the class, right? So, FFP you are very familiar, right?

I've been often using this, right? This is the fourth class I'm using this term, right? Now, this course, right, if you go abroad, right, this course is actually called the Front End Design. If you go to any foreign country what we call as system thinking, they will call it as front end design. What is this front end design, sir?

Okay, let us look at it. Right? This is a new, right, new figure I am showing you. What is this figure all about? I want complete attention. Guys, wake up please. Right, all of you are slumping. Sit, sit straight. Right. So I want, right, [02:09:00] next ten minutes give me undivided attention. This slide is extremely important.

Why is it important? I will tell you. Okay. So, think about, when a child is born into this world, right, what does it do, what is the first thing it will do? Can you stall? It tries to, let us say it has got some consciousness, it is able to understand who it is, right, 2, 3 years old. What will that fellow do?

Can you make that fellow stop in a place? Can you make him sit in a chair? That child is going to go everywhere. So, what is the fellow doing? Exploring. Right, it wants to touch everything, feel everything, fire it will go catch fire, it will burn itself. It will not remember, it will do it twice, thrice then it will know, oh if this thing it will hurt me, that is discovery phase, right.

What is discovery phase? You are in discovery phase now, right, in product design, right. We are at the initial front end, where when you start, right, I spoke about fuzzy front end multiple times, [02:10:00] it is not a linear progression. Design is non linear, ok. I cannot emphasize this. Design is, what is non linearity?

Again I have to define what is linearity, I have to define what is, ok. What is linear? I have a sequence set of steps, sir. First do this, next do this, like a flow chart. They said, I cannot do that, unfortunately, especially in the initial phase in the discovery phase where I'm discovering, right. You don't even know what the problem is to begin with.

Yes or no, right? Should I do this? I have this problem, sir. He says, I have two problems, sir. Can you quickly review that is what one of the, one of your friends asked me, right? Because he does not know what is even a problem. He's not sure. Right? So that is the discovery phase. Right next is cyclist. You go to diagnosis.

What is diagnosis? Right, I will talk about it in detail, right. So, discovery phase will, right, through half of September will finish. I will teach you what is called your construct [02:11:00] matrix, right. It is a semi mathematical approach, right, little bit qualitative and quantitative also, ok. And you actually do the actual design and then this is something not in our, we will only stop here, we will actually stop here.

What is it? 6th. 6th sem. 6th sem. You will actually make a prototype and call it today. Unless you want to get it on to production, right, you really want to take it to the next level, right. You do not top late it, ok. You have to understand this, ok. So, here, right, we call this the fuzzy front end of the product design.

It is a chaotic phase with no clear cost effect rule. There is no engineering. What did I say? When you have low complexity, there is clear cause and effect. When you have high complexity, it is outcome based. But when you start, it is highly chaotic. You do not even know where to start. It is very fuzzy.

That is why we call it FFA, fuzzy front end, right. [02:12:00] Now you should understand, ok. Let us take software for example, ok. Why am I talking about software? Little bit you can follow, ok. Right. Let us take software for example. Software will typically start with. Either design, diagnosis, or design. Why? Let's look at income tax website.

Okay. Common example I give, okay. I think info is made. Okay? The current income tax website is made, right? So I have a website and I'm not going to discovery. How should the website look? Who is my customer? How will they use it? This is not the question I'm asking. I know my customer. What is the tax, tax paying user base?

I think 2 or 2, 3 crore, right? It is just, it is a fraction of the population. Ok. Mostly level of customer, I know that. How much tax are they going to pay? I know that, right? I have a template actually. You understand? I have got a template. [02:13:00] So, they are not asking, it is not like completely, right, chaotic for them.

It is not a chaotic design process. They are pretty much, they are starting actually Because they have got a base to stand on, okay. Now suddenly, government is saying, let us start a digital healthcare scheme. Where do they start? No idea, sir. How should the website look? No idea. Right? I have no, I have nothing to refer to.

Right? Let us say if I am writing Indian constitution. Right? If I am writing Indian constitution, what, what do we do? British other things we referred, right? It's not completely chaotic. We are reference, if I are the first guy, first nation on the planet to write constitution, what is even a constitution, right?

I will start with random things and then slowly evolve it over time, right? So if you are doing what is called a new [02:14:00] product development, NB. Okay. What is a new product for a CS guy? Right? A new product maybe? Yeah.

Or it can be a piece of software,

right? Or it can even be an algorithm

on a mechanical engineer. What is new product design? It may be a consumer product,

right? Or it can be an industrial machine. It can be anything. Right. When I am starting, think about this. Digitizer I am using, so this is the requirement, right, I as a customer, as a teacher, I am asking. Some engineer is there, from the logic I can say, dude, what I want you to do is I will write with my pen on my notebook.

Somehow you should capture it and broadcast it and show it to people not them. [02:15:00] I don't even know how to do this. You got a pen that writes on a piece of notebook. How should I do it? I have no idea. Let me figure out. Understand. Now you have a stylus. You've got a writing pad. It's obvious. You have a reference.

Now you're starting here. If you're doing incremental product improvement, what does Windows do? I have no idea. Now, Windows 11 is there, right? Windows 11, when they start, they will go into the discovery. They will clean the slate, they will say, we want to build a new operating system. Windows 8, have you heard of it?

Yes, sir. Right? Windows 8 was, in my opinion, the riskiest project what Microsoft has done. Why? You know what they did? They took actually a very bold approach. Microsoft has since not ventured into that space, right? What they tried to do was, Right. They said, okay, Microsoft understood, [02:16:00] right, when did Windows 8 come by the way?

When? 2008 or 9, right, exactly, I don't know the exact year, right? 2008 or 9, right, about 15 years back. What Microsoft did, right, they understood mobile phone is going big. Guys, I hear some talking. Mobile phone is going big. Laptop is there, PC is there. So, somebody in Microsoft asked that question. Why are we making separate operating system, right?

One for your phone. Windows phone was 2010, they bought Lumia, Nokia they bought. So the question they were asking is, why are we spending so much resources in making one separate tone down version for my phone, little bit stronger for my tablet and a fully fresh version for PC? Why can't I build one operating system that runs on any hardware?

It's actually a nice idea, but implementation is where they had a problem. In terms of processing power, mobile phone uses how much power? 10 watts, 15 watts. How much does your desktop PC use? 100 watts. So the processing power varies [02:17:00] accordingly. So at least in theory, many people actually, even within the team, they have a lot of disparity.

Read about the case study. Many people disagreed. They pointed this very problem. We do not have the computational power. I cannot run a fully fledged operating system on a mobile device, right? And if I tone down that, what happens? You are going to irritate the PC consumers, right? They took a, I think it was Steve Baller.

I don't know who was the CEO at that time, right? I think it was Steve Baller, right? He took a call like let us build it, right? They had this concept of tiles, right? If you know Microsoft Tiles, they are just going to have tiles. So what they ended up doing, making a operating system that is meant for mobile, they brought from phone to the desktop.

Everybody hint it. They got it off the top. Somebody started a campaign saying bring back the start button. There was a campaign. Okay, they got rid of it. They got rid of Metro. They had an interface called Windows Metro. Read about all [02:18:00] that. Very interesting. If you, it is a new way, right, for CS guys, very interesting topic, right.

They got rid of all this in the hope of running one operating system on multiple hardware. What Microsoft ended up doing was really ruined the experience for everyone, right. And then, right, they understood the mistake. Windows 10, they actually went back, right. So what happened with Windows 8? It's a failure.

Operating system failed. Windows Vista failed. Massive patient. Okay? Windows 10 made all the corrections. 11 again, they messed up. Now they're correcting service back, right? They played around a bit, right? Many people hated it, right? They put the start in the middle, right? What they forget, Microsoft often forgets it right in the pursuit of making something different just for the sake of being different, doesn't serve.

Okay? I'm going to teach you a very important principle, okay? In fact, I'll write it down to you. Change, okay, [02:19:00] for the sake of change, okay, very important principle in this, for the sake of change,

is the ideology, okay,

of the, can somebody complete it for me? Change. Change, for the sake of change, is the ideology of the cancer.

Okay. Given by a guy called Edward.

Okay? What is a cancer cell? Cancer cell is actually what it is. A mutation. It is changing. Is it a good change? It'll kill you. Okay. This is what often, right, when you get into discovery phase, right? You have to deal with all this, right? I gave you a case study of Microsoft, right? Where they stuck. This is why Indian companies, they don't get into the.

Because of failed, lost billions [02:20:00] of dollars, what it finally do? Apple got into Apple car. You have heard about that project? Right, there was an Apple car project. They scrapped that product, 10 billion dollars or 20 billions. They scrapped it, is it? If we pursue, right, there is something called sunk cost fallacy in economics, sunk cost fallacy.

What is sunk cost fallacy? If Apple had pursued their Apple car. Instead of losing 20 billion dollars, they might have lost 200, 300 billion dollars. Why? I have put in 200 dollars. Let me invest even more and somehow try to make it work. When you see a clear path, right, this is not going to work, right? You have to abandon sometimes, right?

That's why even Microsoft, right, abandoned the Lumia. They had this Lumia 9. Right, they bought it. Nokia, they bought it. And then finally they said 1 billion dollars I think is what Microsoft lost on the project. They scrapped it, right? So, understand the importance of discovery, right? And diagnosis, right?

Most [02:21:00] incremental innovation starts with the diagnosis phase. It is a, it is a development. Sir, I have a template to follow. I will make some small changes, few difficulties that the user faces, I will change that. If I am starting afresh, I have got a clean plate. Problem is, I can mess up bit time also, right?

Always remember the Windows 8 example, 8 example here, right? Then I go to design and you can go back to discovery and design, right? Look at the arrows here. It goes from diagnosis, goes back to discovery, then comes to design, then goes back to diagnosis, goes back to discovery. Why is it doing this? Why is it doing this?

Design I told you, it is non linear. This is why I said it is non linear. It is not just this outside cycle, it is the inside cycle also that matters. Got it? Right? So, typically what you are manufacturing or you are, uh, Any IT company that does, that, that claim to do software development, actually, they do not even get into design, they will be [02:22:00] operating in this space.

They will develop, right? They will be doing this. Maintain a software, send, keep doing that, right? So, you can be anywhere in the loop, right? Understand this, right? This is the important thing I was talking about, right? All these influences, right, whatever I was discussing about, are potential sources of data for discovering new product concepts.

It gives me an opportunity to play, right? Usually involves people from different divisions with different specializations and priorities, right? Important that whatever role you choose, you sensitive, you are sensitive to the problem discovery, right? Don't use the tool you know to solve a problem, okay? Be tool agnostic.

What is being tool agnostic means? Sir, I only know Python, so I will stick to Python. My day, okay, if you knew C sharp, right, you are king. If you knew [02:23:00] Java, you are king. Now, hardly you will get a job if you knew, if you know C or C sharp or Java, right. Tools change, but if I can code, if I can write a piece of code, does not matter if I am 1990, 2000.

I am here today. Right? What is A? It does not understand. A does not understand context. You see, we have already under, we have highlighted this. Right? A can run beautiful codes, but what it fails miserably to do is, right, understand the context and code for that. Right? So, you have to be sensitive to the problems that you are discovering.

Okay? Data collection methods. How do I, how do you collect data? Right? So, data collection methods should increase complexity for better problem understanding. I am not asking you to solve the problem at this stage. You are in discovery phase. Don't forget that. Right? You are like a child wandering.

Understanding, getting your hands dirty, [02:24:00] getting your hands burnt on a flame. Keeping your hand on a piece of ice and feeding the hot and cold, multiple different textures, differences, and so on, so forth. So on. Right? So you have qualitative and quantitative data from primary. What are primary sources? You actually, you are talking, if you're working on a forming problem, talk to a farmer.

If you're working on a medical device, talk to a doctor, right? So talk to the primary data source, right? So, this can be an observation, interview, it can be a group technique, and a secondary source. What is secondary source? Research, right? Go do a research using Google Scholar, right, Microsoft Academia, you can write a report, use articles, right, so on and so forth, right, write a source of knowledge.

You can actually go to LinkedIn, talk to your seniors, talk to somebody there, right, get some data there also, right. Different types of data. Data can be an image, can be voice, text data, right. So what is the outcome of this, right? You need to have a problem discovery document [02:25:00] using which we will construct a matrix, right?

This matrix is n by n. What should be the size of the discovery matrix? There is no standard size, okay? Some n, right? Towards the end of the course I will give you an actual discovery matrix from four folders, C and all that. The size of the n will be 200, 250, massive. But for you, okay, stick to 20 or 20 pairs, right?

You cannot handle 200 variables. 200 and 200, right? 400. You'll just go mad. Be too much for you to process, even if you have a large team. So you will restrict your end to maybe 22. Yeah, maybe right? 20 to 20 pairs. Two, they can be, this is what I suggest. Okay? Discovery size of your right end by 25. By 25. 25 by, not itself is huge.

Okay? Right. Okay. So, this I will go in, right, deeper detail with a case study next week. I will, I will talk about this in greater detail. Okay. Now, [02:26:00] quickly, let us quickly talk about diagnosis. What is diagnosis, sir? You go to a doctor and that fellow, what is the first thing he will do? He will put a stethoscope on your chest and say, breathe.

What is he doing? He is trying to assess the situation, right? In other words, he is trying to diagnose, right? So, diagnosis is using complex infinitesimal to extract the creative, holistic and rigorous problem definition, product concept, right? So, this I have not explained in detail for now. This is like a n by n matrix, just remember that, right?

From which we are going to see pattern extraction. We are going to see some patterns and we are going to pull that out, right? Why is this pattern important? So, That is the source of innovation, do not forget that. So, we will use that to basically define our problem statement, ok. Look at this, initial interest, ok.

Can you make out anything out of this? There is just grey and light dots. Here, nothing. Here, I can see some eye, some nose, something. Here, you can actually see [02:27:00] face of Einstein, right. How many inputs are there? Oh yeah, that is 27. How many inputs? 80. How many inputs? 2 38. How many inputs? 825. What does it tell you for you?

Right? The initial interest is like this. When you discover your data, is this, when you diagnose, right? The inputs actually goes up. Actual design rate, more inputs. That's the whole point, right? And there is a question here, right? You know what this is about play, right? Do you know what this is? What is the golden ratio?

Uh, what is Fibonacci series? No, no, don't give me the mathematical definition, right? Look at most, uh, art in nature, right? Right, for instance, right? If you take a shell, Right? You can actually, [02:28:00] Fibonacci series uses this example, starts with this. Right? Your sunflower bettel seeds, right? Your architecture, architecture it is used.

Okay? Photography, photography, when you photograph a person, right? Rule of thirds, have you heard of rule of thirds? Right? For instance, if you are photographing your friend, and if you photograph in landscape, which hardly anyone does these days, right? You do not keep the subject in the middle, you keep the subject to the left and show in the background, yeah.

That is one principle. If you look at a professional photograph, they will not keep the subject centered. They will keep them either to the left or right, right. If you actually study photography, you will learn all these concepts, right. So, that is what golden measure is all about. The key takeaway from this slide is, right, the more inputs you add, the more complexity you are increasing, which is a good thing, right.

The better will be your problem space, ok. At this, I will leave it as an example, ok, right. Another important skill you should develop is, right, if I give you a paragraph like this, ok, [02:29:00] literally, right, I am giving you this paragraph first, don't read the title, ok, forget the title for now, look at this, read this.

no plan files B2, B3 are drawn from Bill O'Reilly's book about Rain factor. RDO, RDO, RDO, RDO Alrighty. B2, next. Are you all, okay. No, first, you can all mask them. Is that right? So, your point, your focus right in, right now has to be that headline. You are reading many different things. And what are pulling out patterns, right?

Okay, department of heavy industry, okay. They are announcing a plan, car maker. See, car maker and all, it is not there, right? Department of heavy industry, car maker, right? Vision for electric car, all that is combined into electric car fleet. Is there a word fleet anywhere there? No. You see, but I am extracting a [02:30:00] pattern.

Okay, and I am using a equivalent thing, electric car fleet by 2030. You understand? Right? And it does not say ministry of heavy industry, all vehicles, right? So, no plan at present, right, to have all electric fleet by 2030. This is how an editor's job. It is very difficult. An editor has to see the whole thing, right?

They give a, they have to make a trailer, right? You know how difficult it is? I should not give the plot of the film. Right? But I should give just enough, so you will come and watch my movie. Right? Which means I have to show you the important parts also, but not enough, so that may, enough that makes sense, but leaves you hanging like, what the hell happened in the film, let me go watch it.

Rather if the intent is, if I am giving you a summary of a film, I can also piece the clip in such a way, right, such that in 30 seconds, I show the whole film. Hero came, villain is there, they fought, villain died, hero is victorious. I can, I can have that, that sort of a timeline also, [02:31:00] right? So that is the important skill you have to learn.

Similarly, right, same thing, right, you take, right, the key thing, right, without getting the specifics, what the skill I want you to practice, I will give you the slide, you do not have to photograph, right? Stop. The key skill which I want you to photograph is, not photograph, which I want you to keep in your mind is, right?

So. To look at patterns, right? Systems thinking is all about, right? In fact, I would say, I would even go for so on, so, so far to argue your ability to look at patterns, right? is critical. It is crucial to actually solve problems. Why? Why is this so important? I will give you an example. Yesterday, chumma, I went to, uh, one stationary shop, okay?

I am always looking, right, new ideas of making new things, ok. I went into the, uh, crosswords, right, there is one shop, right. Always when I go to crosswords, I do not go to the book section, I go to the stationary [02:32:00] section, ok. They will have something interesting. There is a brand called ERI, E R I. Have you heard of this brand?

Ok, they have, ERI. They have all the acrystic pencils, uh, they will, they have got staples and so forth. I came across one Japanese brand, right. I forgot what it is called, right. That is one Japanese brand. They have a stapler. It is all written in Japanese, right? I know it is something interesting. It is all in Japanese, right?

And I see two, three of it hanging on the shelf. So I just take one. They have a nice picture. They have a stapler like this and then they put an X. Then I go, what the hell? There is a stapler without a stapler, right? Then I understood, right? Okay. Oh, it stapler. I bought it, right, it was very expensive, took it home, it worked beautifully, right.

But limit is, it can only staple maximum of 5, 5, 5 papers. [02:33:00] That is the limitation of it. It is also mentioned in the package. It is 5 sheets of paper like this, 5, they put a limit there. How is it able to do that? It is able to take that, right, staple it. Literally press it, squeeze it so hard. Right. And the paper literally fuses with each other.

Right? So it strength is pretty decent. Right? So what is, I'm trying to tell you when you're looking at stapling, right? So this, I should step back and ask that question. What is the problem? Somebody's talking about waste management often. I tell them, if you're interested in waste management, go understand what is waste and go understand how is a waste generated.

What is waste in this case? Used pen. That is a dangerous thing. Why is it a dangerous thing? Look at the poor guys who have to handle the garbage. It will go in their hands, lick everything. You have children, you go to write all these waste processing, all these open spaces. You will have children playing on the garbage, [02:34:00] right?

Often you will have nails, right? All this, we will toss all this in the dustbin, right? With no regard to finally where it is going to end up, right? So staple, if I get rid of the staple, all the better, right? Right? So that is the pattern I have to see. That is the whole, that is the whole point of this course, to be able to zoom out and then look, not only the bird's eye view, not only a holistic perspective, but able to identify potential sources of intervention, innovation, right.

So that is the point of right there, got it, so similar example, right. With that, right, I end today's session, right. I'll let you go a bit early, right. So, understand the underlying complexity, right. To quickly summarize, guys, last two minutes. What did we learn today, right? The key things that we have learned today.

What are they? Guys, stop. Probably I should stop. Stop staring. I should just end the session and say. Right? What are the key things we learned today? Right? We learned the power of [02:35:00] seeing the whole and parts. Parts. And what we understood is formal measure of complexity. How do we measure complexity? Variety.

What is variety? Right? Variety is a measure of complexity. Variety you measure by number of elements. How are those elements connected to each other? The type of relationships? Whether the relationship is one way or two way, whether it is on or off, depending on that, it can be, right? It can be combination, permutation, or it can be even exponential, right?

That and what does , we looked at the model, right? Where you have a system, formal definitions for a system, innovation and design, right? What is design? It is a pattern that is not actual distinctive. Which is empathetic and it is engaging. Okay, so that is formal definition for design. Then what is innovation?

It is also a pattern that is an attract, that is dynamic . [02:36:00] Got it. So these formal definitions of mine, then we looked at system itself, boundary, open system, closed system. And what is complexity itself? Complexity is a good thing, I told you. Complexity is not a bad thing. We need complex systems so that they are dynamic, they can actually adapt to changing circumstances, right.

So, right, I hope this gives you a broad overview, right. Assignment 3, I will post it, right, by today or tomorrow morning. It is still about 5 10 students have trouble. I will sort that out, right. Any of you have trouble with the MS schemes here in this class? You have a problem, did Send me a mail, write, I put a thing, reply to that mail, to the mail, write, create a Office 365 account, write, if you don't do that, I cannot even manually add it.

Anyone else has any trouble? Right? So, please, as I said, at the beginning of the class, create a folder, right? Share it with me. The link to post the folder, I'll give you one per group. Understood? Right? Stop here. [02:37:00] Right, I'll go post all the notes. Please go back. Right. Right. Right. Right. Right. Right.