Technology Forecasting for Strategic Decision Making - An Introduction
Professor. Bala Ramadurai
Indian Institute of Technology Madras
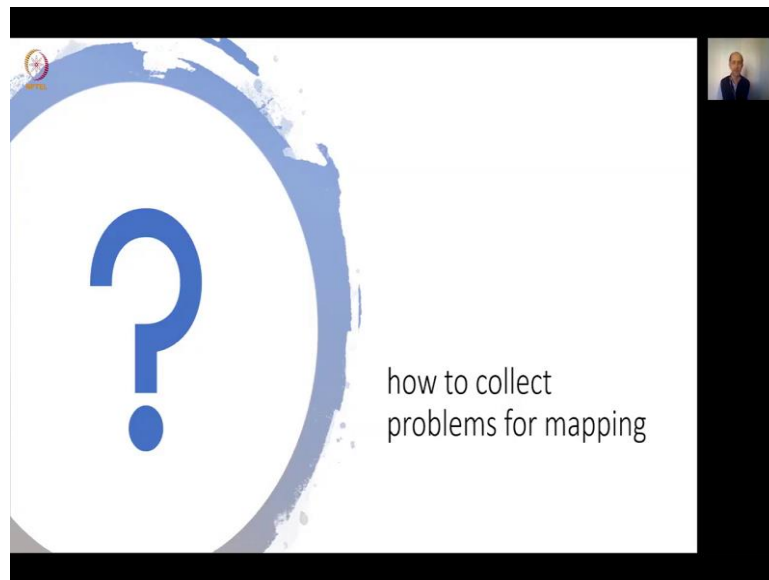**Professor. Dmitry Kucharavy**
EM Strasbourg Business School
**How to collect problems for mapping**

Professor Dmitry Kucharavy: Welcome back to our course about technological forecasting for strategic decision making. And today, we are going to see -

(Refer Slide Time: 00:29)

How to collect problems of mapping. How do we systematically collect problems for mapping and why we need to map problems, why it is not enough just to collect problems from experts? For collecting problems for mapping, we are using our system operator as a source, as a departure point. After that, we build a list of drivers and barriers, and out of this list of drivers and barriers we are building our list of problems. Let us try to understand the process.
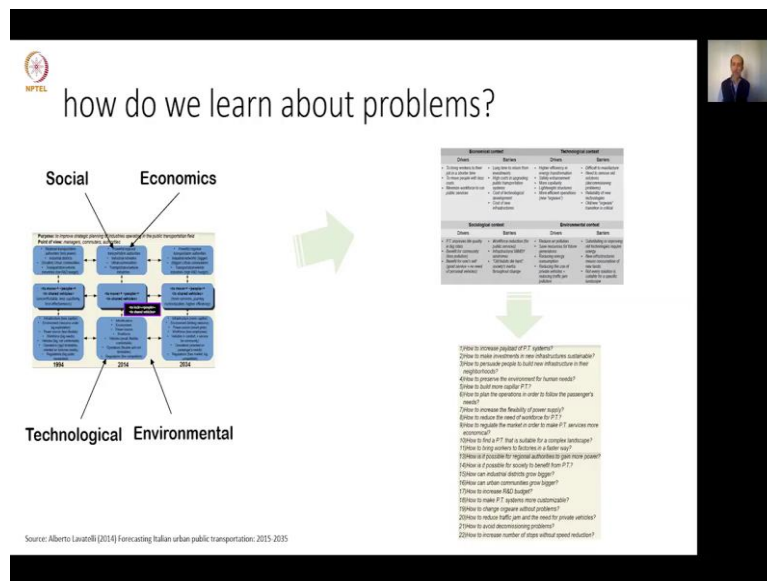
So, how do we learn about problems? First of all, we try to build our system operator. Here I am sharing with you one of the examples of project, students' projects about study about a public transportation system in Italy. When we built the system operator, what we have? We have a definition of the main useful function of the system, we have a description of the super system, description of subsystems and past of the system and future of the system from a certain viewpoint according to the certain purpose of the study.

In fact, when we are doing this, we try to observe our situation from several point of view, not only from a technological point of view, as most of the study about technology forecast is given, but we also try to see from environmental, economic, and social point of view. What are our super system which need our system to operate? Thanks to the building system operator for the past and present, we can recognize the trends which our system experienced from past to the present and using these knowledges, we can systematically analyze what will be the trends which will continue or we will change in the future.

And the transcends the super system helps us to understand what will be the portrait of our future system, how it will be different from the present one, not just using intuition and not using our limited knowledge because our knowledge are always limited by our experience, but systematically using the rules and procedures from a system operator.

What is next when you have a system operator and we have some trends? We can, on the basis of that, we are building our list of drivers and barriers for these four contexts. How do we formulate the drivers and what are the guiding line for drivers and barriers? In fact, the drivers and barriers. This is something that drivers, this is something that motivates and helps us to

follow the tendencies that we wrote in our system operator and barriers, this is something that prevents us to follow those tendencies, because uh! and trends.

Because the barriers this is as usually limitation of resources like energy, materials, knowledge, in order to satisfy the trends that we discovered in border of our system operator. So, step by step we collect the least of drivers and barriers, but not only from technological context, but also from economic context, from social context, and environmental context. This takes time because it asks for certain expertise and for certain knowledge because usually, it is not enough just to build an exhaustive list for the technological context or environmental context it is necessary to observe our system from that menu, these four perspectives.

And the combination of those perspectives for instance, economic context plus social context can provide us business context, or environmental contexts in the economic context can provide us also legislation context. The combination of those contexts, in fact, cover all, most of the viewpoint that can be purposefully applied in order to build a list of problems. Do you remember, our main idea is how to learn about problems systematically?

What happens next, out of our list of drivers and barriers, we reformulate all collected barriers into the question, how to bypass them? All those ways sometimes we realize that barrier formulated in our list of drivers and barriers is not really the problem, we know already the solution, we know already how to answer this question, how?

For instance, in this particular example, we can see that about 26 barriers was reformulated into their list of problems, 22 problems which are formulated in a way that we do not know the answer, and those answer we need in order to satisfy the tendencies that we learnt using system upgrade on the level of supersystem system and subsystems. So, those problems not only about some component of our system, like public transportation, but this is also the problem about supersystem. For instance, how to regulate market in order to make public transportation services more economical?

So, those list of problems in fact, this has to be checked for the consistency for our study using system operator and for our drivers and barriers. The main mechanism, how do we improve level of risk, how do we reduce level of subjective influence personal biases, and cognitive limitation? We try to verify the consistency of list drivers and barriers and system operators they have to be consistent. It means if you have a problem in the list, we have to be able to trace where is from this problem from which tendency it comes from the system operators and if the system operator, we have nothing, we have to review our system operator.

The same we are doing with our technological, economic, and social, and environmental context when we looked through the drivers and barriers. What happens next, in order to help us to advance towards to the system view of our problems, we use this list of problems as a source to formulate contradiction.

(Refer Slide Time: 09:27)
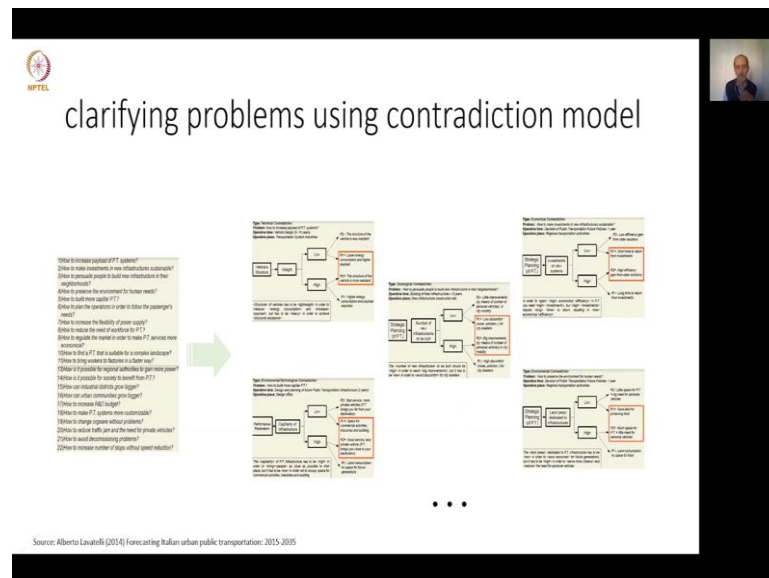
In fact, the main idea that we clarify our problems, we clarify these lists of problems by reformulating them in the shape of contradiction. But the beginning, this is a set of contradictions. It means we are building the list of definitions of how to according to the formal rules. We are going to see these formal rules later. But those formal rules helps us to learn in deep about each question, how?

As a result, we have a list of contradictions, which seems at this stage of analysis, they seem not so well connected. So, the deeper understanding, what are behind of this question, how, allow us to formalize our knowledge and to improve our knowledge about future tendencies which we realized with the help of system operator and which we realize with the help of analyzing drivers in various form for context.

So, output of this activity usually can be 24, if you have 22 questions how 22 contradiction we have to formulate, what happens in reality sometimes the number of contradiction increase, we can see that one problem calls formulation of several contradictions or vice versa, sometimes, on the process of formulating contradictions, we realize that our question, how to, we know already how to answer it so, the number of contradiction decrease, this is how it works in a practice.

But in order to check once again consistency of collected problems, what we do that the next we try to connect them into the system because the one of the main features of any kind of system, of any kind of connected components and this is distinguished from the set that we have a new emergence feature will appear. So, we use the connectedness of this contradiction, which at the beginning are not connected to the map in order to check the consistency.

(Refer Slide Time: 12:28)
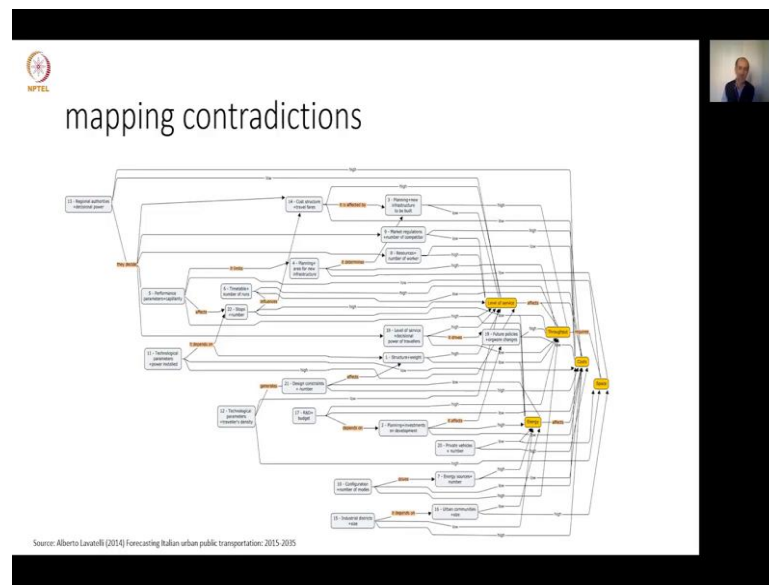
So, in the particular project about public transportation in Italy, future of public transportation in Italy, the map of contradiction constructed in both of these projects look like this one. On this diagram, you can see that each contradiction are interconnected with critical to x features or with dimensions and the problem are also interconnected among each other.

What is interesting to see that through the map and contradiction through connecting them, we improve the quality of our list of problems, we improve also the consistency of our study, we can clean our professional biases and we can fulfill some cognitive gap about the system because what happens that within the process of connecting contradiction, we can see that some something is not connected there are some empty spot, there are something that has to be aggregated.

So, several problems are aggregated into one or another kind of problem which is more generic article improves by several problems. This is exactly how it happens. And this is from a methodological point of view one of the main advantages and main purpose, why do we connect our contradictions into the map? This is how do we trade our qualitative data and how do we try to improve their level of formality formalization because it is qualitative data, there

is always the same problem that we have to manage that they are very much biased by a knowledge of experts and by knowledge of people who are participating in a study.

And we do this process which is started from definitional boundaries of our system using system operator followed by collecting drivers and barriers, out of drivers and barriers, we extract list of problems, which we check for the consistency we formalize this list of problems using model of contradiction. And we interconnect those contradiction in order to have a system view of map of problems, which drive evolution of our system.

This was all that I would like to share in this introductory course view about the mechanism that we use at the basis in order to perform qualitative part of our study. Later on, we are going to see how do we formalize our problem to the contradiction in more detail. Thank you. Do we have any questions?

Professor Bala Ramadurai: Yes, Dimitri, thank you so much for this you made it very clear, why we do this and what goes into making this I have one question around the drivers and barriers and this I have received from many learners in the past when we have attempted to do the drivers and barriers. How can we be sure that the drivers and barriers are correct? And are proceeding in the right direction? As a learner, how can I make sure that this is all right and is there some kind of checks and balances? That you can suggest.

Professor Dmitry Kucharavy: Yes, thank you. Thank you for the question. And this is not easy to manage this question. I do agree with the issue. And usually, we use the mechanism, when we check the consistency, the consistency between what is the scope of our system and the scope of our system, we realize what are the tendencies.
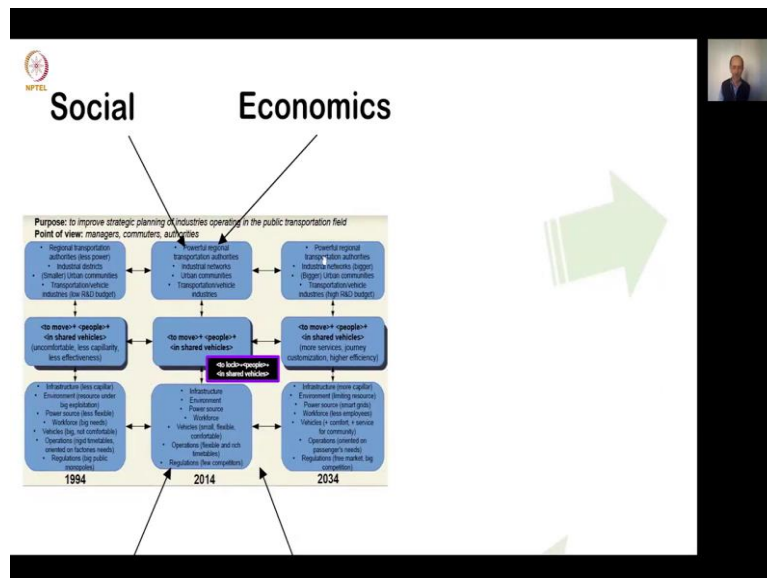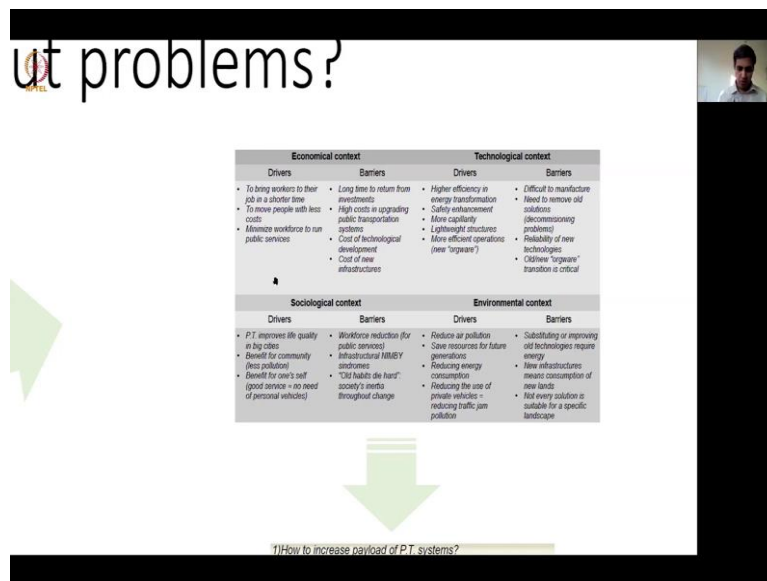
But when we start to build our list of drivers and barriers. This list, of course, it is limited by our knowledge, our existing knowledge about our system. So, that is why the process to build list of drivers and barriers usually takes time because this is a time of very intensive learning about why those tendencies that we recognize are still not take place in our reality. And this is intensive learning and to be sure, to be sure we use just the process of consistency.

For instance, we have a tendency about urban communities and urban communities are going to be bigger,ok, just you can see on the screen and we try to see the reason of this tendency from four different perspectives, from four different viewpoints. And if we have just one viewpoint like from social context, just because population grows, it is not enough. We try to

learn also why from technological context, it will be possible or not possible, why from an economical context, it will be possible or not possible.

In fact, the suggested framework in border of a former project it was named TEES technological, economical, environmental, and social. These frameworks force us to fulfill the gap of knowledge that we have in order to improve the confidence with what we build. This is how it works.

Professor Bala Ramadurai: Okay, thank you so much. I think that helps to bucket under these four categories so that we are sure we are covering all the perspectives of drivers and barriers itself. So, on the topic of barriers, I think you already referred to this but I still will go ahead and it say this. We do we take the barriers from this list that we have where in the drivers and barriers. The reason, I reasoned out is that in order for the system to evolve, these are the things that are holding it and we need to figure out further analyze and find out what actually goes into the barrier. Is this the reason or is there something else, did I get it completely wrong? Just wanted to clarify this part.

Professor Dmitry Kucharavy: Yeah, this is a reason you take it properly, this is a reason, but usually the barriers they present to ask different kinds of limitation of the resources and those resources can be a limitation not only about energy, not only about materials, not only about space, not only about time to introduce to the market for instance or time to perform certain process, but it can be also limitation about knowledge, it can be also limitation about perceptions, social perception of certain technology on the market.

And in fact, the future of system depends how we will be successful to resolve this limitation. And it can happen that we are not capable to resolve this limitation. And in this case, the future of technology will be questionable. Let me give you example just to make clear what I mean if I take into account the technology about fuel cell, which is a very promising technology to produce electricity with minimum pollution because the by-product of this process is not just clean water.

But the question is we are limited in order to put this technology in practice, we are limited about rare material like platinum, that we use as a catalyst for the low-temperature fuel cell. And for the high-temperature fuel cell, we are limited because this is a high temperature we are limited by materials, which can sustain high operation temperature, and this problem until now is not answered adequately.

So, those limitations plus limitations how can we store hydrogen-rich gas and how can we deliver it to the place where we are going to. Assume that those barriers are not answered, those contradictions are not resolved. The future of our system is questionable, this is how it works. We build the map of knowledge in order to see to have educated guess. What can happen within a time about technology?

Professor Bala Ramadurai: Okay, makes sense. Thank you so much for that. This is also from a learner's perspective. Dimitri, oftentimes when I totally loved the map of contradictions. Because in one shot, I can tell what is happening next, it is anaccumulation of many things. A lot of hard work goes into putting it all together, reasoning it out. But when I show this as an example to a person who has never seen mapping contradictions.

The first reaction is, oh my God, how long is it going to take me to build this? So, what do you have to say to somebody who is thinking about, what sort of resource, let me okay, that is the lighter side of things, but on a serious note, how many people do we get? And how much of resources do we put in to generate a map like this?

Professor Dmitry Kucharavy: If you are talking about maps like this, that you can see now on the screen, this map was elaborated by one student, within a course, when he learns about, he wrote about methodology, it means he wrote about methodology and about public transportation system in the same time and those goals was academic course 64 hours.

But in fact, the answer for your question depends on what kind of granularity we would like to have? It means the more detailed map we build, the more time it will take, the more contradiction will be on the map, the more time we will spend and more team efforts. In real case, for an adequate level of granularity, for strategic decision-making at the company side, the good idea is to have at least four specialists from different domains around the table.

Like one from a technological domain, another one from economical domain, third one from environmental impact, and from social domain in order to collect systematic way the problem and usually this process can take from 8 to 12 working sessions when we are talking about working session, this is something about two hours prepared in advanced session. In this case, the produced map can be purposefully applied for the strategic decision on the company level.

And usually, how do we use this map? We take, for instance, certain emerging technology like, we are talking about blockchain for the operation of the warehousing system. And we just check the map of contradiction for warehousing system. And we see how many problems on

this map the blockchain answer and are those problems are critical or not? It helps us to take decision to step in or not into this technology domain and to spend resources of the company.

So, there are two things for the expenses to build this map, the level of granularity, which is useful for taking strategic decisions, but the map that like I presented right now for you. This is a relatively short period of time, in terms of many hours. Within one academic course, this map was constructed and the conclusion which was built in with the help of this map was also applied in practice. Did I answer your question, Bala?

Professor Bala Ramadurai: Yes, absolutely. Thank you so much for that. One follow-up question I have Dimitry is I know the answer, but I want to convey to the learner because we have discussed this on for a while now. What tool do you suggest somebody take up to build a map like this? Because the utility of it is immeasurable, I have benefited out of looking at a map like this. So, what tool, a software tool do you recommend that somebody use for making a map like this?

Professor Dmitry Kucharavy: In fact, thank you for the question. In fact, for building map like that, you can use whatever you want, you can use even PowerPoint or you can use any editor which can manipulate with boxes and connections. But what we do use with our students in practice, we use CMAP tools. CMAP tools which is output of interesting project which is an ongoing project for decades in order to manage knowledge within education process.

This is a knowledge management system and the concept map allows us not only to draw a different kind of diagram but when the diagram becomes a bit more complex than what you can see right now on the screen. In this case, you can extract the data, the node's connections to the Excel file and manipulate it using as a matrix. And this is quite useful in comparing with all other software and this is CMAP tools.

This software is downloadable free of charge and you can use this software not only for building maps but also for organizing your knowledge about different domains. I do recommend your model of this course but also in both of other courses in order to build consistent map of your knowledge about different things. We can provide the link but you can just google CMAP tools, and you will arrive to their website of human, I will share the screen right now just a second, please. Just to give you an idea of what kind of screen I am going to see when you will arrive because, …

Professor Bala Ramadurai: Yeah, I have used CMAP in the past and found it to be very useful for organizing information in a visual format and to convey it to people also we have used it. CMAP and there is another tool called VUE - Visual Understanding Environment, which is also useful in presenting information as well as to building information. Yes.

(Refer Slide Time: 31:10)
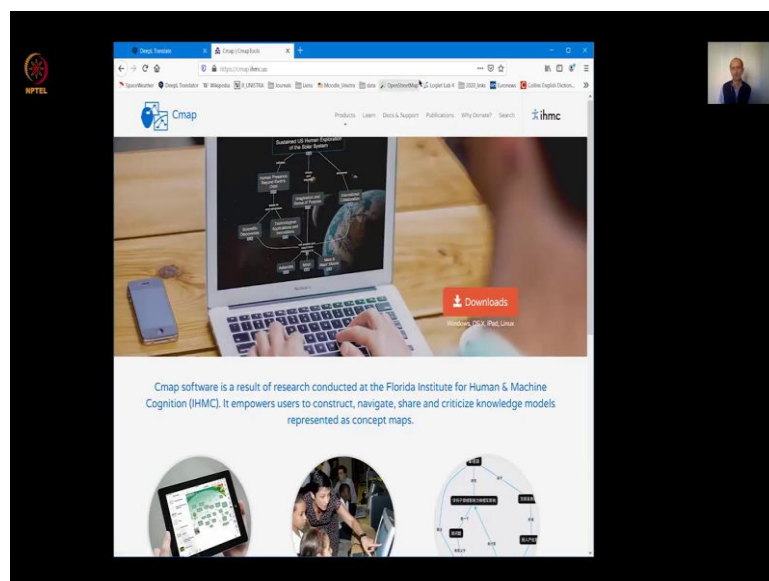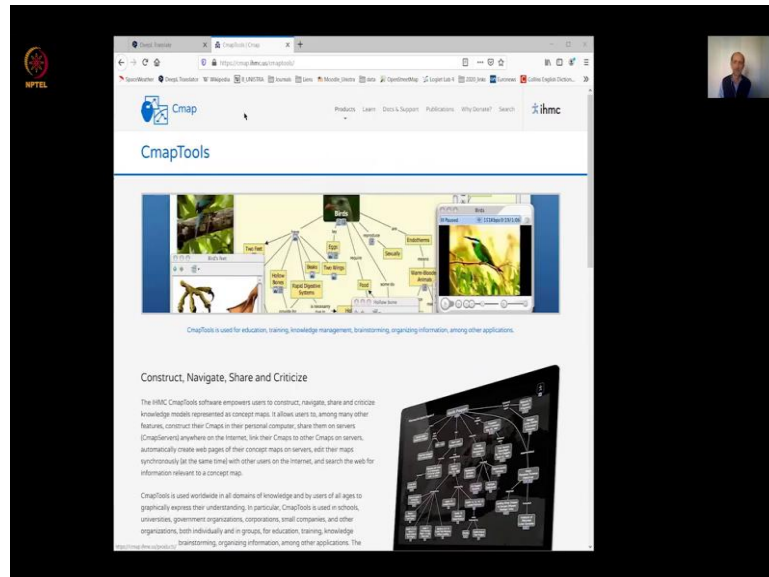
Professor Dmitry Kucharavy: Yeah, this is a website where you can learn about CMAP that we are using and for mapping contradictions, because today, the CMAP tools, they are quite popular, there are different sources in different softwares. I am just sharing with you what we are using with our students regularly in order to organize our knowledge about contradictions. So, you can download and you can use it, your welcome.

Professor Bala Ramadurai: Yes, and it is available for all platforms. And,…

Professor Dmitry Kucharavy: Yeah.

Professor Bala Ramadurai: It is quite handy.

Professor Dmitry Kucharavy: Yeah.

Professor Bala Ramadurai: Thank you, one last question about the map of contradictions, is regarding the yellow blocks that we saw. These are derived and I remember, again, I am ahead of the curve when compared to a learner because we have discussed this, but I just wanted to bring it to the front that these have to be 5 plus or minus 2 nodes so that we can make sense of it. Am I wrong or right, Dmitry?

Professor Dmitry Kucharavy: Yeah, Yeah You are right, in order to keep it thinkable because whatever model we use, as one of the great scientists said that all models are wrong, but some of them useful. OK. In order to be useful, and in order to be thinkable, it is recommended to keep number of dimensions critical for the future dimensions, not more than 5, ok somehow, 5, 6, not more, and how do we arrive to those dimensions?

In fact, when we aggregate, when we generalize our desired result out of a list of contradictions, we classify them into the 5 groups, those 5 groups appear, the name of our demand, critical to x dimensions, critical to x features that we use in order to interconnect our contradictions, in order to keep it thinkable. Yeah, they have to be 5, 6, but not more. Did I answer your comments?

Professor Bala Ramadurai: Oh, absolutely, thank you, thank you this is critical. So, which is why I thought I should bring it up. And as a you know teaser for a learner, this we will definitely are thinking about an advanced course where we will bring it all together. This is meant as an introductory course. So, we are going to stop with this level of introduction because it requires more detailing and more work.

But you would highly recommend that if you are a learner and you have come across this, you are you find it very interesting, which I do find it interesting also, you should apply it on real problem, real forecasting decision, I m sorry a strategic decision and you are begging a technology forecast for that you should definitely apply and see for it yourself. So, that is fodder for our next course.

Professor Dmitry Kucharavy: When you put your own hands you can learn, I do agree with you.

Professor Bala Ramadurai: Yes, learning by doing absolutely.

Professor Dmitry Kucharavy: Learning by doing, thank you very much.

Professor Bala Ramadurai: Thank you so much.

Professor Dmitry Kucharavy: See you next time.