Technology and Innovation Transfer: Hamburg University of Technology as an Example in Germany

transcribed plenary speech of
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Ladies and gentlemen it is an honor to be here and give you a talk. I was invited to give this talk, which is really pleasure for me to be here and I was somehow in this idea of professionalism, engineering and tech- nology transfer. So first of all I would like to ask, who has been to Germany already? Okay one!. Who can tell me how the congesting control of TCP/IP works? No one! Okay then I think, I am with the selection of what I am trying to do, not too bad. When I want to tell you two stories. I hope I would somehow keep the time. There is a German joke, Professors can talk about anything but not in less than 90 minutes. But I should try to be less than half an hour.

Okay, so what I thought about is, one question I want to answer why is he doing and what is he doing? As you have heard before, I am a professor for com- munication networks. And who the heck can some- body be interested in communication networks? Pro- tocols and how the machines communicate with each other? That is what I want to highlight little bit. And I also want to highlight little bit how we do technol- ogy transfer, innovation and engineering in Hamburg University of Technology. Because this is second part of my job at the moment as I am the vice president of that university. I am responsible for research, innova- tion and technology transfer.

Okay, Lets think about communication networks. Why is it exciting? This has something it has to do of course with mobile phones. And this speed of things chang- ing. It is dramatic and exciting because it is something which is difficult to understand. Difficult to realize and it also changes our personal life. That is what makes it more interesting. I want to highlight a bit of history of what we see. This is a picture I have seen in many many conferences over the last couple of years. Say the last two years. You know the Pope in Rome was reelected after the first one died and it was only after eight years later. You see the picture, when people were waiting, for that is what people say, for the new pope to come and to show. You see on the left side is 2005 and the right side is 2013 everyone has an iPad or a mobile phone or smart phone doing the pictures. Wait, the first lesson for today is, this is a fake. Although I have seen it 10 times in differ- ence conferences. Because I was googling and trying to find the original pictures. Then I found out the left picture is not the election of the first pope but it is when the predecessor died. So it is not really true, but still tendency is the same. The first lesson never believe anything if you do some research and always check the issues. The other thing I wanted to show here is how fast things change. I was doing my mas- ter of science in 1994. The mobile phone at that time, the lease rate for that is more expensive one than for a Mercedes Benz.

What we see then is two things. That why I have this open from 2001 to 2014. One thing in 2001 for the first time, these are the world wide figures, we have more mobile phones than fix line phones. That was the first thing we never could believe in. They were with the introduction of GSM and in the middle of the 90s and then 10 years later we have more mobile phones than fix line phones. The other thing is, this purple line here is the percentage of world population which has smart phone, and this is world wide. Blue line is the percentage of the world population which has mobile phone. So 95% of world population, math- ematically and theoretically, has a mobile phone. But some of us has two, I have two, one in Sri Lanka and one at home.

Nevertheless we have managed to have seven billion mobile subscriptions in the world. So we also see that this is something not a luxury good anymore as before and anyone more or less can get hold of it. We change society. Every thing has changed. I am not trying to agree where to be, I just call when I am there. So has these really changed my life. So I can really send my daughter somewhere, give her

the mobile phone and can call her when I want to. The other trend, which from this purple line here, is within few year only, 2007 to 2014, we have 32% of world popula- tion could get a smart phone. Okay, still some have 2 phones, but generally something around 32% people have phones. This will again change the society. The second question is what is next? So we see a satura- tion. We have three or four times smart phones. We would expect 95% in next 5-10 years. What's then? what does our industry do? Anyone has an idea what would come next? Well I don't know, no can see the future. What we see clearly, that what is next, is the internet of things and machine to machine communi- cation is next dimension. You can easily think about having, 10, 100, 1000 devices may be per person, con- necting somehow home window, front door, connect- ing smart meters for electricity, electric generation to- day, so may be this all these things might come to- gether. And there is a prediction, that we will see something at 27 billion mobile to machine connections in 2024. Of course this is nothing really simple for us. It is not just adding a new dimension. It is something which is giving some differences.

At the moment we are optimizing mobile networks to have high data rates. So what we do is, we do re- ally smart things. We think about where we are, we think about what kind of the channel would be easily estimated channel that we decide what would be best to increase the data rate to 10 Megabits per second. And this is quite an effort. Now I want to transmit one piece of data, door is open, door is closed, 25 KWs used in last 10 hours. This is really good data, and therefore I have 27 billion devices. So have to redesign the service, so this is one thing which is really differ- ent. The other thing which is really different is the big variety of different requirements. We have data which is something like temperature reading in the room , if it comes now or in next 10 seconds makes really no difference; if the air condition goes on early or later, no difference; if you think about smart grids, and pro- tection circuits, it might be important to have it in a few milliseconds. If you talk about controlling devices, why are the internet removed control something like a surgery of a patient, thinking about chemical proces- sors where can't enter the room where I do something like a remote control? I need to a hectic response, and that is milliseconds or less. Then I might not have to have or may not be allowed to have any errors. And this is very difficult to model and to do.

So, talking about challenges, as I already mentioned here, we see very different requirements to see. We have to put them into communication networks. We have to talk about reliability for our applications. Ex- citing part of what we are doing is, that we can apply all the different things. We can think about medical technology, remote medical treatment, we talk about smart grids for energy distribution and consumption, we talk about the city of the future. And you see that is not only something which you need in the developed western countries and cities; this is something you al- ways have. You need to think about how we control the traffic and you can do it either by, well I know that some day of the time it might be busy, but what if there is something not just garbage collection blocking on the road I just have to bypass it. I should know it. All these things I can have with sensors, I can commu- nicate with the car and the mobile devices. They can communicate with each other and they can get a bet- ter and more livable world and this is something we see on traffic; this is something that you can see on energy flows. You can see them in waste garbage col- lection and you can see that on other resources which you need like gas, water and so on.

Okay, and then of course well, I was trying to draw a bit what is the future. I thing you see that there is a high potential and we need a lot of engineers working on this area but then of course the question is can our IP network which we have since the 80s that is what I was asking TCP/IP no one knows how does it work. But everyone is using that, I am sure for that. Because any web process is using TCP/IP. And the question is this was designed for accessing computer centers via copper cable. Security at that time was the guard at the entrance of the computer center. And today we use it for all the viable things for our economy. We use it for daily communication with friends or business. It is without internet and communication the world econ- omy would be a real problem, also I think we have much more problems. So that the question which we have to ask is will the internet satisfy our needs of the future and today's needs? And there is something we really don't know yet and then you can think about what is the University doing and University should do something nice. Of course as a university we have the pleasure or we have the freedom to think out of the boxes. So in this case we can think about what would happen if I want to design the internet today? To- day's applications, today's technology and maybe to- morrow's applications and tomorrow's

technology, in view. How would I do it? I would do it completely dif- ferent and that's for sure. Because I would not do it in the way I do it. because many things I'm just doing for information for content. And I don't really care what the content is. The content is secured. I don't have to think about which machine it is. So maybe it can just do something nice I want to have a connection to the projector and this room because I am feeling hot. These things you could do. And you don't have the IP address of the devices.

Can we do that? Well, in the eighties we had a flag table when we introduced TCP/IP and all machines at a certain time of the day had to switch to the new IP protocol. This is probably not possible anymore. And we did some research in this area we came up to something smart idea with virtualizing all the net- works. Same as you do it with a computer, you have Linux, Mac and Windows operating system all in the same machine or inter machines. We abstract to use the core functions. We can do the same with routers. With processor you can just set one for IP one for any other type of protocol. This might work. And what we see now that was something naive 5-7 years ago the research, but today everyone talk about network func- tion virtualization, at least functions like billing, au- thentication, media gateways, some kind of firewalls. They are virtualized and you can move them to the network where you need them. That's the first part. Okay but this is the heart which we have with net- work virtualization. And software defined networks. I am not going to too much details. I think I have to talk about TCP/IP first.

Okay so, if we talk about ideas what Universities would think about free thinking, question things and have something nice. We should also have sound eval- uations because that is what we are good in. Industry is working multinational, they work together over the complete world. How can the university or bunch of universities would be better. And the thing is we can be more thoroughly, think about how can we model it properly and how can we have the methods to the sound analysis. And there is something which we al- ways see and strengthen that is why I see that somestudents here as well. Think about what we are do- ing there. Today the trend for the papers of confer- ences goes to more and more experiments. You have a world wide test bases you can use but today there is a re-scalability need to do something more. And if you talk about billions of devices you can't have even billions of course which you can connect to which ma- chines. So how can you prove it? And the other ques- tion is if you want to be reliable have something to 10 to -12 reliability you have to stimulate this 10 to -12 events several several times to have any idea all experimented.

So in the end there's no way around to have all mathe- matically modeled that's why you need to have sound mathematical background in engineering education. okay. And of course if you look at University there are some methods we have to teach. These methods we have to further develop and apply. And we have to cooperate with industry to develop new things and we also have to think about can we apply things in advancement for human beings and society? It is also leads to the next part of my talk somehow because the University of Hamburg of Technology has the technol- ogy for the human being as long as their main objec- tive. And then we want to educate innovative there's a question how to put use innovative engineers and also responsible engineers. Yes we should think about what are we doing what can we use it for? Is it reason- able what we use it for or not? And this is a question that we had to do in education.

Okay so, then just briefly coming how do we do re- search in my groups? So I introduced before I'm the head of an institute, an Institute in Hamburg. It's dif- ferent in different universities, it may need Professors that I'm training 10 PhD students and some engineers. And looking at what is the challenge are, we decided to go for a future Internet for planning as one of the tasks. I mentioned already the different architectures can be just have instead of IP addresses just the name of the data. How to put a name, how to do the rou- tine, quite a number of interesting questions, we think that this equal applications will be a challenge for the future, will be more and more wireless, we talk a lot about how to do the scheduling, and I think if I can't see it at the moment, Thushara Weerawardana here as Dean of Engineering Faculty, he was with me in Bre- men and Hamburg and did work on the mobile net- works cases. And then of course if you think about how to apply all the technology the Internet of things and center networks is the way we want to see most of it.

Okay. Speeding up a bit. I will show because you al- ways have to show one equation that one understands. We basically come in the research to

methods of which are always coming the same thing. So we think about expressions, we think about simulations, we talk about modeling and it is a tough method, Sim Cards and net- work cards like things. But you simply find completenetwork and there's what you see in this middle box here. You can simply find computing network to the main button there and then if you can mathematically describe arrivals and departures, your Professor Per- era also knows quite well,you can do a lot. And we spend some like one year to develop with simulator. And two months to simulate model, and the model was 10% accurate in the end. This was just what I want to say about this method. If you do it properly it's quite good. But you have to validate this again when you need in the simulation mode.

Okay, maybe just one thing also if you talk about bachelors thesis , master thesis, just one thing I would like to give if you are on the way, if you do something, in communication network or in any other science, you always would think about is this result I have is trust- worthy? Can I use it? Can I trust it? And I have many students even in Hamburg, I asked them what happens if you simulate twice as long? He asked what is okay? And I asked is there anything you can say about the accuracy of the results? He said you can trust me. As I don't want to trust you I want to know if this is correct. And asked him do you know what the confidence interval is and you can calculate math- ematically the accuracy of the result or the reliability. And he knew it. But he did not have the idea to do it in six months masters thesis. And that's what you have to think. Always question your results. That's just one point I want to give and basically we see and why like you so much communication technology, communica- tion networks is mature. Society relies on it.

We have a great performance, we have a high complexity, but this is not the end. We still need to have ul- trahigh reliability 10 to -9, 10 to - 12 , for the new ap- plications we have in mind, and the industry automa- tion. In the medical applications, and we have to think about how to model this network. So research is still I am required. Just a short outlook, on the second part, how does a German university work? I think I have to speed up a bit. Everyone knows where Hamburg- ers is. This is the map of Germany. Hamburg is the largest European city which is not a capital. We have 2 million habitants there. And it's rather the north so we also have a big harbor, like Colombo has. It's the second largest Harbor in Europe. We have the second largest aircraft production location. Airbus is doing that, Hamburg is the second-largest. And of course we have a lot of trade. Not too much science though. We have a university with 40,000 students, in our univer- sity is rather new, so this traders which were in the city of Hamburg thought about well we might need some engineering in the 70s and they finally found it Hamburg University of technology in 1978 and now we have something like 7000 students 20% international, 100 professors roughly, something like 670 research assistance which is plus criteria, which is Master level plus. And we have something nice interesting we have something like e110 million. And one third of that is acquired by external funding. And that's what I brieflywant to talk about.

Okay. It's about how we get the funding. And but first, may be just an idea what we cover. It's a pure engineering University. Almost pure. So we have mechanical engineering, we have civil engineering, we have electric engineering, nice thing is that this is in the same faculty like computer science and math. And then we have some management science and technol- ogy. They basically tell us if you do resembling what we do, if it's worth it, and we have some educational processors which help us in doing a good teaching. And at the moment, because we are so small, we can quickly adopt. We are winning different prices for our innovative teaching in Germany. Academic careers in Hamburg or, in German universities in general, you basically do after 12 or 13 years that's something in the turnaround at the moment are A level. Then you do three area bachelors, and then you do a two-year masters, which is a full-time study program, and then you can do a PhD, and interesting thing is there are several interesting things. Firstly, thing we typically don't have study fees. There is some universities, most of the universities are public which we don't charge. But the cost of living is rather high in Germany.

PhD programs are typically not structured. We have some graduate schools which have structured pro- grams. But mostly you go to professor and he has to provide the funding for you. And the nice thing in en- gineering for the PhD student that they are paid the full salary. That's bad for us because we have to pro- vide the funding. And typically we have few positions from the University. And the rest we have to acquire. So we would write project proposals, we get money for projects, research projects which we do, which has some good objective,

could be some new development in architecture. We do that with companies like Erick- son and Nokia. But this is quite tough to do. And we need have to have full salaries for each and every PhD students who is working on it. And we do projects funded by national ministries for European Union, and by industry. But there are also some scholarships like German exchange service (DAAD). And then we skip a bit. Of course if you have seen different schools, we have the different programs, also interesting that we have international English taught Masters programs, and you see that information communication systems, for example the one which I'm heading. But there are also different other engineering areas which we have it. Coming visiting master students, they are always mixed with German students in the courses. So in the end we teach the masters all in English. Which is good for the Germans as well. Okay research you do in the different faculties we try to focus ourselves, because the politicians can count to three typically. So we have brain technology, life science technology, aviation and maritime sections and we have the schools for teach- ing and research is done in research centers which direct into this different competent fields. And then we have the different research centers which some- how they are dynamic. And they work together 10, 14, 15 professors and they are on the same fields and try to interact and have interdisciplinary research and get research projects acquired.

Okay. Just an idea in 2014 we had e35 million exter- nal funding. Most was from the federal state. Some 20% is from German research foundation. Also 20% from industry just to have an idea on that. How does it work? And then something that special in Ham- burg is that we had the first spinoff company where we have 50% of the shares which do indirect indus- try projects, and they also do patent commercializa- tion. That's mainly what they do. We have 62 full- time employees at toTech. That's our daughter com- pany. We have around 200projects we do with them. And budget is something like e20 million per year to do these projects and some number of small things. The nice thing that is not in this university is that at Belcrest University we have much more flexibility of doing things. And we have quite a good IP com- mercialization agency that was found in 2001, seven employees, some 800 inventions were disclosed. And was evaluated. And something like 20 to 30 setups are supported every year in this context. Then I saw the signs that my fifteen minutes are over.

Okay, I hope you got a message from here. Commu- nication network research is so exciting that you want to come to Germany and do research with me. We still have enough challenges ahead. We have it addressed with industry but we also have parts and questions which we can better do at university. And we have way of industrial cooperation and IP management which have just shown to you.

And then I hope you have some questions for me. Oth- erwise I can just relax again.

Thank you very much.