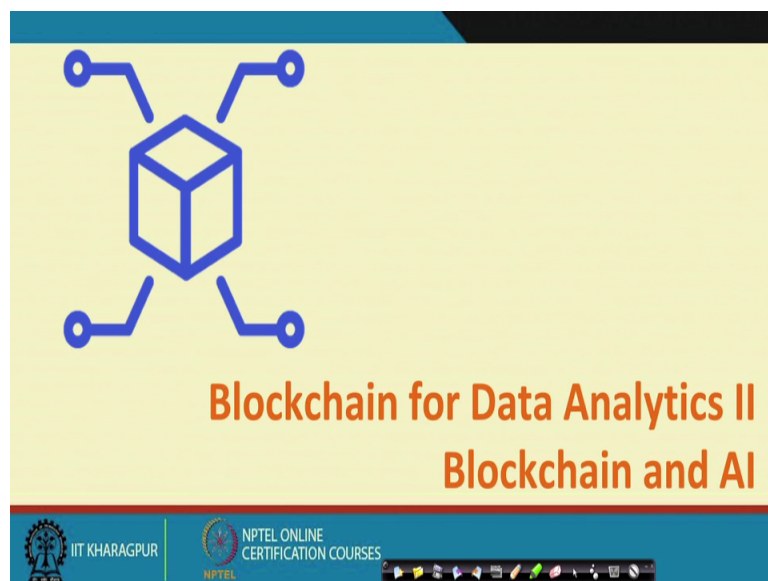


Blockchains Architecture, Design and Use Cases
Prof. Sandip Chakraborty
Department of Computer Science and Engineering
Indian Institute of Technology, Kharagpur

Lecture - 55
Blockchain for Data Analytics – II (Blockchain and AI)

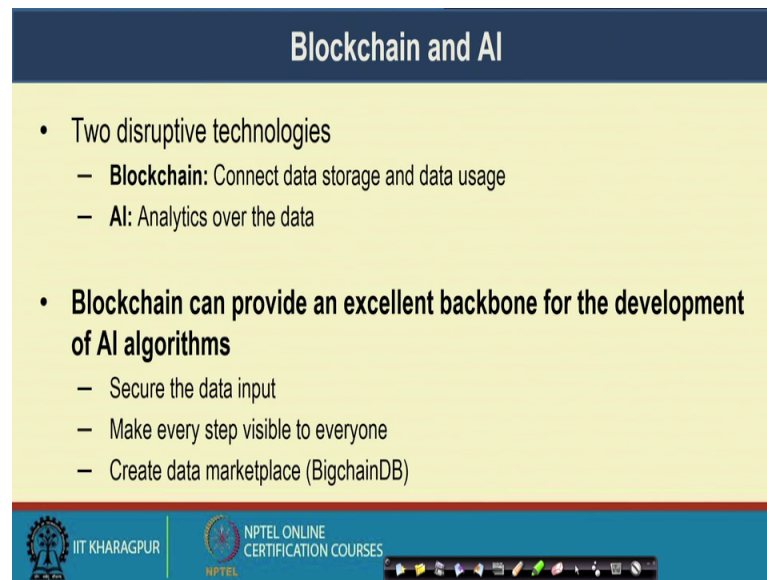
Welcome back to the course on blockchain. So, in the last class we are discussing about the blockchain applications for data analytics.

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So, today we will look into another perspective of utilizing blockchain for artificial intelligence and machine learning applications. So, that is going to be some interesting use cases, that we are we will be discussing in this lecture.

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Blockchain and AI

- Two disruptive technologies
 - **Blockchain:** Connect data storage and data usage
 - **AI:** Analytics over the data
- **Blockchain can provide an excellent backbone for the development of AI algorithms**
 - Secure the data input
 - Make every step visible to everyone
 - Create data marketplace (BigchainDB)

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So, this blockchain and AI are 2 disruptive technologies in today's world, where the blockchain can connect data storage and data users from multiple (Refer Time: 00:55) domain altogether and as we have seen in the last lecture that you can have a global data sharing architecture or global data market using bigchain db from here, you can collect the data and you can run execution other queries on top of that.

And whereas, this concept of artificial intelligence, that helps you to run different kind of analytics application on top of the data that you have. So, blockchain it can provide excellent backbone for the development of AI algorithms, first of all because of secure data input. You can get the data input from multiple geo diverse data storage location; which can be under the control of different (Refer Time: 01:43). So, the example that I was giving in the last class, so, it may happen for certain kind of metrological data analytics, you require the weather data which is in one government department, you require the data from the land registry record which is with the another government department, you require the flood data which is to a third government department.

So, that way you can actually connect multiple data sources altogether; where data is owned by different agencies or different stakeholders altogether. So, that is the advantage of utilizing blockchain for AI applications. The second thing is that interestingly, it make every step visible to everyone. So, whatever you are doing on top of the data. So, whatever applications you are running on top of the data a blockchain makes the things

visible to everyone. So, the data owner can find out that for what purpose the data has been utilized or what type of algorithm has been executed on top of that data. And third it can create a data marketplace using the bigchain db that we have seen in the last class. So, that way we have a good opportunity of connecting blockchain and artificial intelligence altogether and develop interesting use cases.

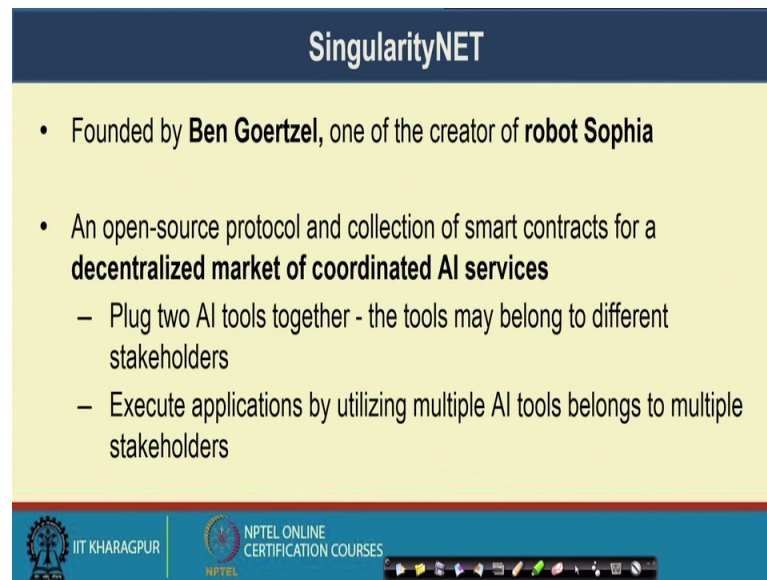
So, in this lecture actually I will discuss about 4 such use cases; where the concept of blockchain and the concept of artificial intelligence has been combined to altogether. And people have developed nice applications out of it.

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So, the first use case that we are going to discuss is called singularity net. So, singularity net that provides a global AI network. So, let us look into the functionalities of singularity net. So, I will in this particular lecture I will not go to the details of these use cases, I will just give you an overview about the power of this use case, and give you some idea that in which point they have utilized this concept of blockchain technology. So, if you are interested to you can always browse the corresponding website and read the white papers to know more details and the more insights about it.

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SingularityNET

- Founded by **Ben Goertzel**, one of the creator of **robot Sophia**
- An open-source protocol and collection of smart contracts for a **decentralized market of coordinated AI services**
 - Plug two AI tools together - the tools may belong to different stakeholders
 - Execute applications by utilizing multiple AI tools belongs to multiple stakeholders

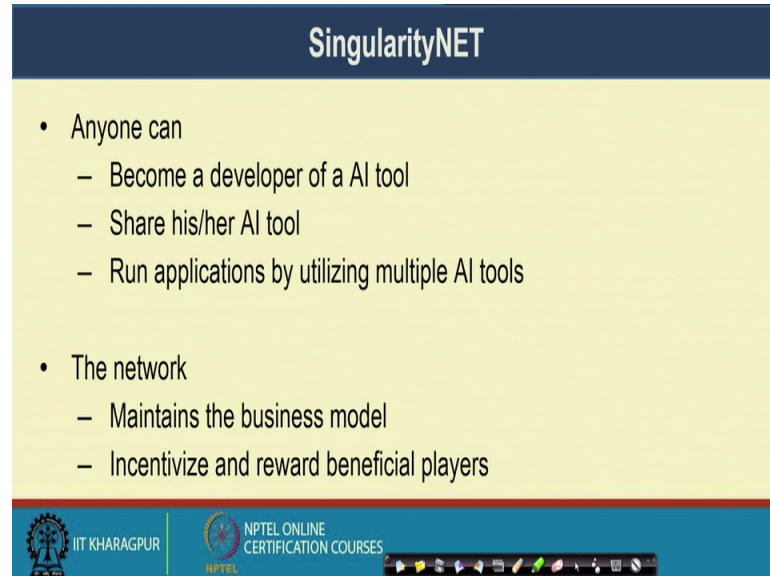
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So, this singularity net it was founded by Ben Goertzel. So, the name of Goertzel is well known, because he was the one of the creators of robot Sophia; who has been granted a nationality. So, the idea of initial idea in the mind of Goertzel was to develop a network or to develop a global AI network which will work as the brain of Sophia. So, it is just like that multiple user they will put the intelligence on top of this architecture, and that will drive the intelligence of that robot Sophia. So, it is an open source protocol and collection of smart contracts for a decentralized market of coordinated AI services. So, yeah you can run multiple AI service altogether. And where the idea was that in the in the complete air machine learning domain you have different kind of algorithms.

And different stakeholders they own different type of algorithms they innovate different algorithms and these algorithms are in the hand of various different innovators. And this SingularityNET it wants to connect all this AI algorithms altogether. So, what you can do with the help of SingularityNET that you can plug in 2 AI algorithms or 2 AI tools together; the tools may belong to different stakeholders with different license in properties, and you can execute applications by utilizing multiple AI tools belong to multiple stakeholders. So, you can run an application particular application which may require 2 different AI tools, and it may happen that those 2 different AI tools belong to 2 different stakeholders. And the data that on top of which you want to run those 2 different AI tools, that data belong to some third stakeholder.

So, SingularityNET will help you to connect all these 3 parties all together, and develop and run your applications on top of the networking platform.

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The slide features a dark blue header with the text 'SingularityNET' in white. The main content area is light yellow and contains two bullet points. The first bullet point is 'Anyone can', followed by three sub-points: 'Become a developer of a AI tool', 'Share his/her AI tool', and 'Run applications by utilizing multiple AI tools'. The second bullet point is 'The network', followed by two sub-points: 'Maintains the business model' and 'Incentivize and reward beneficial players'. At the bottom, there is a blue footer bar with the IIT KHARAGPUR logo on the left, the NPTEL ONLINE CERTIFICATION COURSES logo in the center, and a small navigation toolbar on the right.

- Anyone can
 - Become a developer of a AI tool
 - Share his/her AI tool
 - Run applications by utilizing multiple AI tools
- The network
 - Maintains the business model
 - Incentivize and reward beneficial players

So, with SingularityNET anyone can become a developer of an AI tool. So, you can become a developer a AI tool and you can publish your AI tool under global network of singularity net. You can share your AI tool, and you can run application by utilizing multiple AI tools altogether where as the network on the other hand it maintains the business model for by incentivizing and rewarding the beneficial player. So, if it is like that for your AI tool you have certain licensing property or it has certain price that need to be paid the by the user who is going to use our AI tool. So, SingularityNET will ensure that the amount of money is correctly transferred to you, or the incentive that you want to have by developing that your AI tool you are getting that particular incentive at all.

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SingularityNET Features

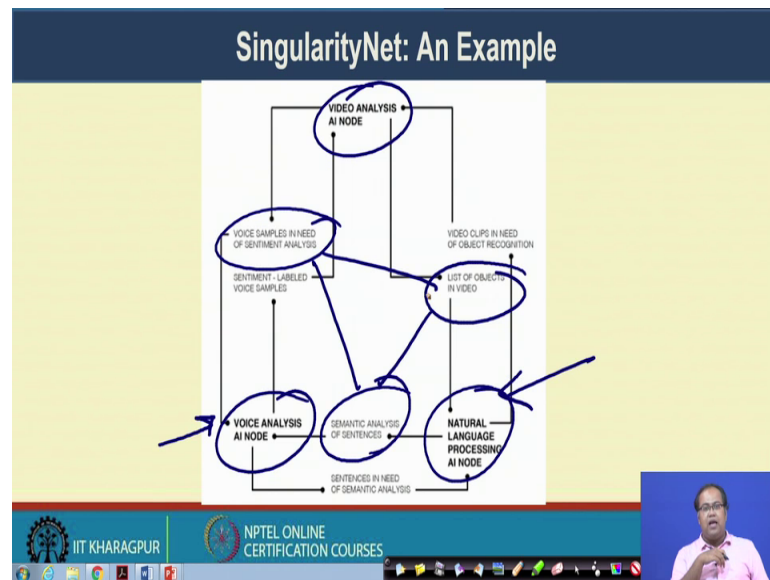
- **Interoperability** - Able to interface with multiple blockchains
- **Data Sovereignty and Privacy**
 - Data access is controlled based on privacy policies
 - Access is validated through smart contracts
- **Modularity** - Create custom topologies, AI agent collaboration arrangements, failure recovery
- **Scalability** - Securely hosts both private and public contracts - scalable and resilient applications can be developed on top of it

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So, these are the features of singularity net interoperability. So, it is able to interface with multiple blockchains. So, it is not like that there is a single blockchain which is running behind. There can be multiple stake stakeholders you can have multiple private blockchains for running private applications. There can be public blockchain for global applications. So, that way supports interoperability data sovereignty and privacies. So, the data access control based on privacy policies of individual stakeholders. And access is validated to smart contracts. So, whether someone is eligible to access particular AI tool or not that is being validated by smart contracts it supports modular design of application. So, you can create customs topologies you can create AI agent, collaborative tbi agent arrangement you can design module for failure recovery and 4th feature is the scalability.

So, you can securely host both private and public blockchain public smart contract. So, it is scalable and resilient applications can be developed on top of that. So, if you want small applications with a few stakeholders wait for you internal agencies. So, you can run the application on top of a private blockchain on top of this singularity networking platform.

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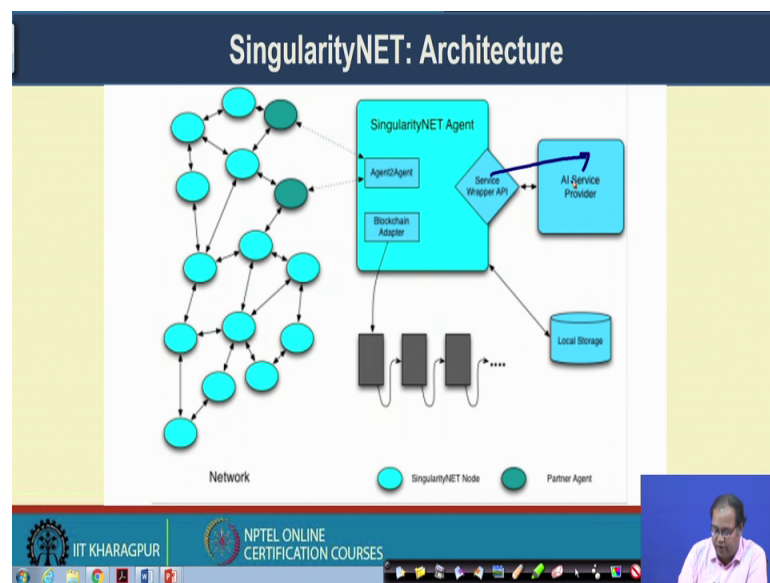
So, here is an example of a use case of singularity. Net, say one particular application it requires video analytics, it requires voice analysis as well as it requires natural language process. Now in SingularityNET you have 3 different nodes, one type of node they have say the video analytic tools with them, where you can run this video analytics tool to extract the video features and perform AI operations on top of that, then under node or this may not be second node under the state of nodes they have the voice analysis tool box.

So, this voice analysis tool box so, this voice analysis tool box this particular node can provide the support with the AI functionalities for voice analysis. Then the third node or third set of nodes they can provide support for natural language process. Now you want a application or you try to you trying to design an application; where you will require support from all these 3 nodes. But the data may belong to one of these 3 nodes or the node may belong to some third party. So, in that case you can actually combine functionality of the nodes altogether. Say here you connect the voice analysis and the video analysis here. So, the voice samples in need of sentiment analysis. So, this voice samples are coming from after doing the voice analysis at node and that is going to the video analysis toolbox.

And video analysis providing this sentiment labeled voice samples from the video data; which is coming to the voice things. Now the sentence data that you have, for that we

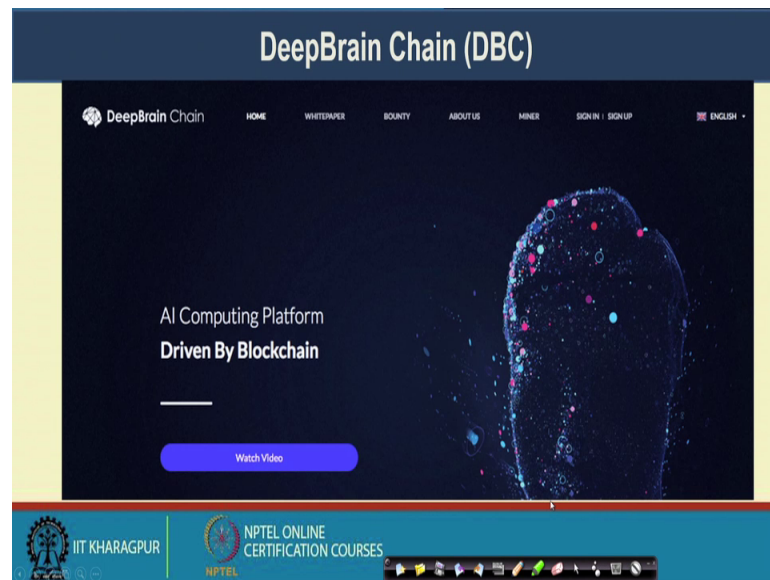
required the semantic analysis which is being done by some natural language processing tool and then this semantic analysis of sentences are return to the voice analysis feature. Similarly, in case of the video, you want to find out the video clips for object reorganization. So, video analysis tool box provide to the list of objects in the video. So, from here you are getting the list of object in the video, from here you getting the voice samples for sentiment analysis, and here you are getting the semantic analysis of the sentence. Now you can coming this 3 to run your application by utilizing the metadata that you are getting after running this individual AI tools ok.

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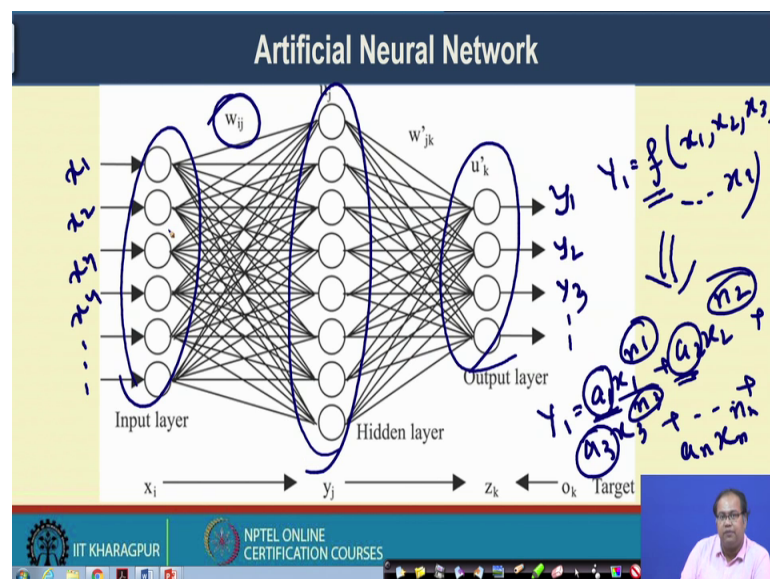
So, this is the overall architecture of the singularity node. Net you have the backbone network. So, it is a complete peer to peer system just like blockchain network. So, this network runs the nodes of SingularityNET agent. So, this agent has 2 different interfaces. One interface is it is blockchain adapter, this blockchain adapter maintains the blockchain under smart contracts to note down every individual steps of the applications or the functionality that has been performed on top of a particular data. And it has service wrapper API. So, this service wrapper API it provides the services, it connects with the AI service provider from where you can get the AI algorithm and execute it under SingularityNET platform. And you have a local storage to store the data in individual nodes, ok.

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So, that is about singularity net. The second few case that we are going to talk upon is deepbrain chain or the DBC. So, this DBC is providing you AI computing platform with the help of blockchain.

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So, to look into that in AI domain is artificial neural network that is an interesting concept and many of the machine learning technologies and this entire deep learning, it is based on this concept of artificial neural network. So, in a artificial neural network, I am just giving a very brief idea of what is an artificial neural network. So, in artificial

neural network, it resembles the human neural. So, you have an input layer; where you have a set of input nodes, and you have an output layer where you have a set of out load, and you have certain hidden layers.

Now, here the idea is that in input you are giving the inputs as x_1, x_2, x_3, x_4 and so on and in the output your producing the output of y_1, y_2, y_3 and so on, now each y_1 is a function of the input that you are providing. x_3, x_4 and so on. Now this particular function is unknown function. So, with the help of this artificial neural network, we want to learn this function. So, you can in general. So, assume that first assume that this is a polynomial equation and f is a polynomial function. If it is like that, then you can represent y_1 as $a_1 x$ to power n_1 plus $a_2 x^2$ the power n_2 plus $a_3 x^3$ to power n_3 and so on, plus $a_n x^n$ to power n ; something like this.

So, here this, $a_1 n_1 a_2 n_2 a_3 n_3$ this factors are unknown. So, with the help of this artificial neural network, these factors are basically computed as the $a_j x$ of individual a_j s between the neurals. So, that is a broad idea about a artificial neural network and this execution of an artificial neural network or better to say the training of an artificial in artificial neural network it is very costly. So, we require large scale servers as the GPU server GPU computing platform to train large artificial neural network.

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The slide is titled "DBC and ANN" and contains the following text:

- ANN algorithms require huge computing power
- A computing platform to support the creation of AI algorithms - DBC aims to reduce the computation cost by 70%
- A decentralized neural network - used to describe a complex ANN based AI system for training applications

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So, this DBC architecture deepchain architecture actually supports the platform to run artificial neural network algorithm in a decentralized way.

So, as I have mentioned in algorithm require huge computing power. So, DBC provides the computing platform to support creation of AI algorithm based on artificial neural network. So, DBC aims at reducing the computation cost by as much as 70 percent. So, it is a decentralizing neural network or they claim is that if you look into the previous diagram. So, this or DBC basically resembles the individual nodes of a neuron. And the computation which is been done being done on top of that particular know. So, that way it is decentralizing this entire neural network architecture. And they claim it is a decentralized neural network architecture; which is used to describe a complex artificial neural network based on AI system for training applications.

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DBC - Objectives

- Make artificial neural network operation decentralized and distributed over the mass nodes of the whole world through blockchain technology
- Via smart contract, data provider and data training parties are physically separated, protecting their privacy
- The computing nodes can be adjusted dynamically according to the amount of calculation of the user application

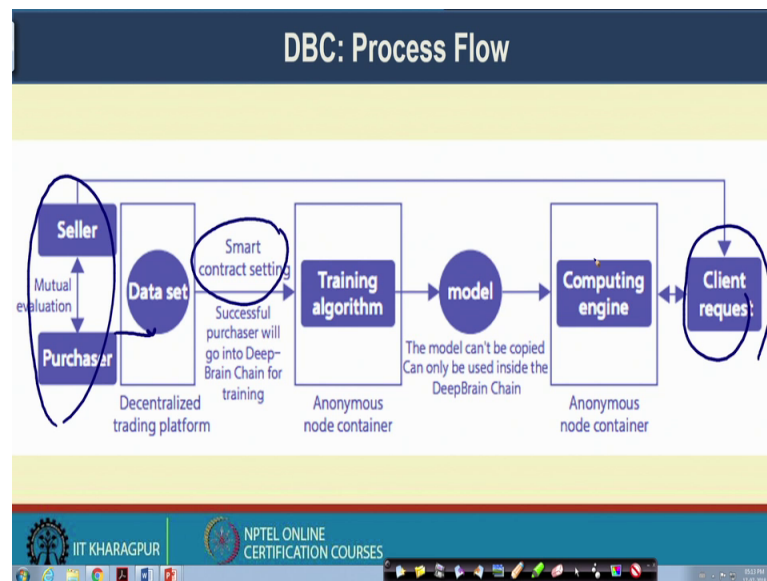
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So, the objective of DBC are this you make a artificial neural network operation decentralized and distributed over the mass nodes of the whole world through the use of this blockchain technology by connecting individual nodes with the help of block chain. First smart contract data provider and data training parties, they are physically separated protecting their privacy.

So, you can design smart contract application for bringing data from the data provider and then running the artificial neural network application on this DBC infrastructure; which is decentralized infrastructure. And interestingly and it is an important features of DBC that the computing nodes they can be adjusted dynamically according to the amount of calculation of user application. So, in a typical artificial neural network,

certain application requires a large number of hidden layers, and the large number of nodes in the individual hidden layers. Some nodes some applications do not required that. So, if you are application required that you can actually involve as many of nodes as you require by scaling up the entire system for running; the corresponding artificial neural network application that you has to execute.

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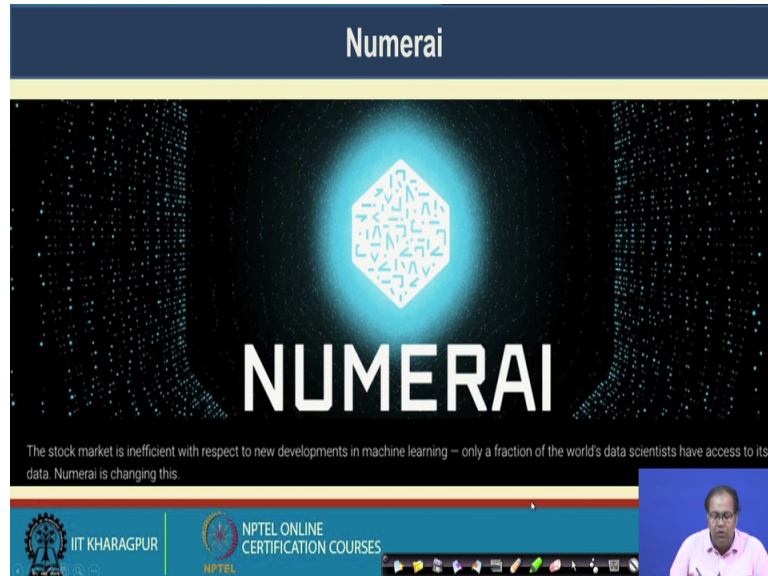


So, this is the process flow of the entire DBC. So, in one hand you have the seller and another hand you have the client request, the seller and purchaser they are providing the data set with the help of a decentralized trading platform, then this data set is being shared with the help of a smart contract. So, successful parties are will go into deep brain chain for training the neural network; so, then you done the training algorithm for the neural network within some anonymous node containers inside the DBChain platform. So, in DBC platform you do not know I mean actual node in which actual node your computation or the, your training procedure is running. Your training is actually distributed among multiple nodes.

So, that way the anonymity of the individual nodes have been preserved. And then you have generate the model, interestingly in case DBC you cannot copy the model, you can only use it inside is deepbrain chain; because now the model is actually distributed among multiple nodes. Now you have this computing engine where you are running your

application you are giving input to that model and the model is predicting certain output which is coming to the client. So, that is the entire process flow for deepbrain chain ok.

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Now, coming to the third use case of utilizing artificial intelligence and blockchain all together; SoHE application called Numerai.

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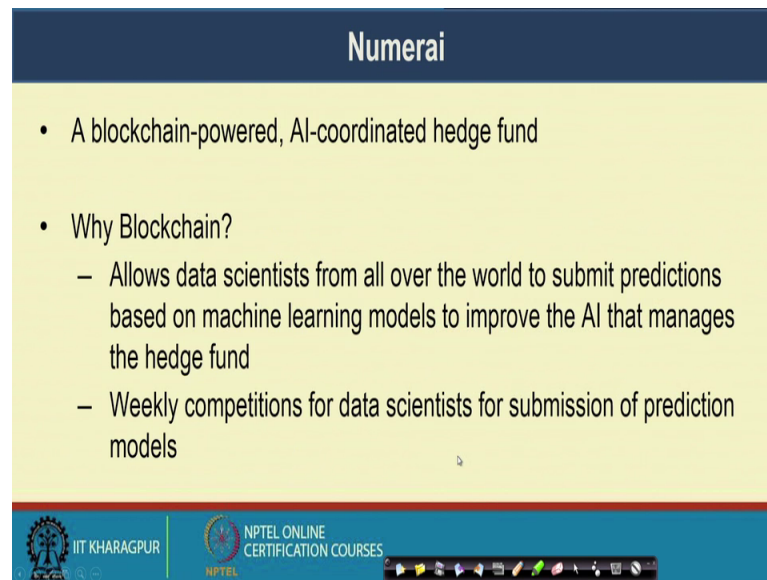
So, this Numerai application utilize something called hedge fund. So, what is the hedge fund?

So, in one of the lectures we have discussed about this kind of crowd funding platform; where in a crowd funding platform you have multiple founders who founds certain projects and there are multiple executor who execute the project and there is a mapping between the founder and executed of a project. Now a fund which is coming from those founders, they are usually termed as an hedge fund. So, a hedge fund one is an investment fund services and definition taken from Wikipedia. So, the hedge fund is an investment fund that pools capital from accredited individuals or investors and invests a variety of assets often with complex portfolio construction and risk management techniques.

Now, the question comes in this kind of hedge fund the system that what is the prediction of success for the investors. So, whenever certain investors are investing on a project, the investors will always look into that what is the success of that project, what is the probability of success for that particular project. Now based on the probability of success for the particular project, the investors will invest more money on that. Now this probability of that success of that project depends upon multiple factors; like, who are involve in the project their history their background history, then their history of successfully running a project, then the complexity of the project different projects related parameters; like, what type of project, what are the different inputs to the project what is the complexity of this particular project.

So, depending of all these different factors the probability of success for investors are getting determined. Now these kinds of things are normally executed with the help of an AI platform. So, normally this crowd funding platforms whenever we are getting the hedge fund. There are multiple AI analytics tool to give you indication to the investor that this is the probability of success for this particular project.

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Numerai

- A blockchain-powered, AI-coordinated hedge fund
- Why Blockchain?
 - Allows data scientists from all over the world to submit predictions based on machine learning models to improve the AI that manages the hedge fund
 - Weekly competitions for data scientists for submission of prediction models

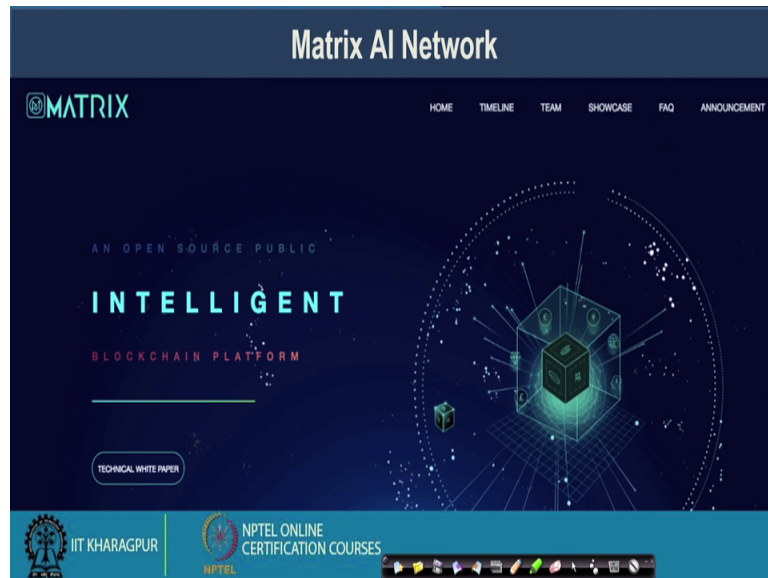
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So, the Numerai it provides a blockchain power AI coordinated hedge fund platform. So, why blockchain, here? Because this kind of blockchain based architecture, it allows data scientists from all over the world try to submit predictions based on machine learning models to improve the AI that manages the hedge fund.

So, different data scientist they can design different kind of prediction model, and that kind of prediction model will run on top of the hedge fund plat fund to find out the probability of success for the investors. Now interestingly here whenever a data scientist will collaborate with the hedge fund, organization or the hedge fund platform the data scientist want to ensure certain requirements. Like, he or she may want to keep that thing secret. He may want to share the algorithm privately. He may he or she may want to get access of certain amount of data. So, this individual request or individual components they are actually won by again multiple stake holders. So, blockchain plays I use on nice use case in this particular example. So, what Numerai does Numerai hosts the weekly competitions for data scientist for submission of prediction models and they execute that prediction model on top of this Numerai network, which is again a peer to peer network powered by blockchain.

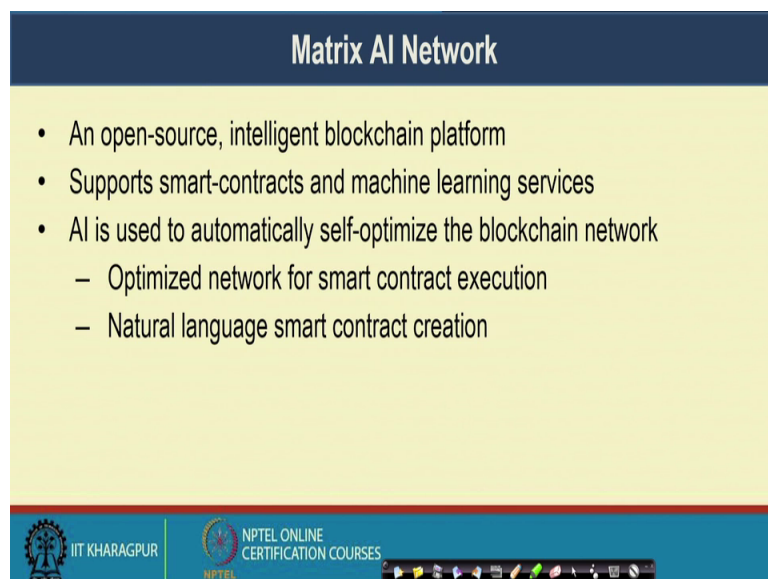
And based on the output of that prediction model these data scientists are incentive high; so, that they can periodically participate in this Numerai platform.

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The 4th and the last application that we are going to discuss it is called matrix AI network. So, matrix promises to design and open source public intelligent blockchain platform.

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So, here are the features of matrix. So, it is an open source intelligent blockchain platform. It supports smart contracts and machine learning services altogether. And artificial intelligence is used to automatically self-optimize the blockchain network. So, you can automate multiple process inside the matrix blockchain platform. For example,

are you can design optimized network for smart contract execution. You can use natural language based smart contract creation and so on.

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The slide, titled "Objectives of Matrix", is presented on a yellow background with a dark blue header. It lists two primary objectives:

- Automatic generation of smart contracts
 - No programming expertise is required
- Secured smart contracts
 - AI security engine for (1) rule-based semantics and syntactic analysis, (2) formal verification toolkit to prove the security properties of smart contracts, (3) detection engine for transaction validations, (4) deep learning based platform for dynamic security verification

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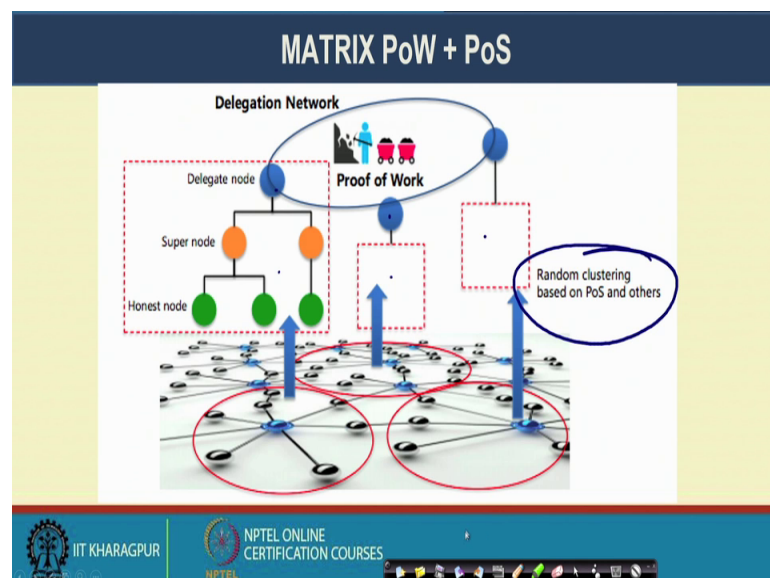
So, let us go a little details about these things. So, the objectives of matrix are 2-fold first of all the automatic generation of smart contracts. So, interestingly currently the smart contract platform that you have like the hyper ledger fabric that we have discussed earlier or the (Refer Time: 23:36) platform. All of them require some kind of programming background. So, you should have a programming background to write the smart contract, based on some kind of programming languages. And then you can utilize the blockchain execution platform to execute the smart contract. But in contrast to that, matrix provide the platform; where you do not require any programming expertise. So, you can express a smart contract, with it is basic inputs. Like what should be the input of that smart contract or output you are expecting, and what should be the execution steps of the smart contract. And then matrix uses it is own NLP, Natural Language Processing toolboxes to generate the programming platform correspondence to this NLP description of the smart contract.

Now, whenever you are generating smart contract in this particular way; that means, the smart contract programs are actually generated by the machines, then there are multiple validation requirements which come into practice. So, another objective of matrix is to secured the smart contract. So, it runs an AI security engine 4 different purposes; to have

a rule based semantics and syntactic analysis of the smart contract algorithm, which is been provided by the user in natural language. The second, it is formal verification toolkit to prove the security properties of the smart contract. The third requirement is to have a detection engine for transaction validations the transactions which are going on top of the smart contract an automatically adjust engine to validate there.

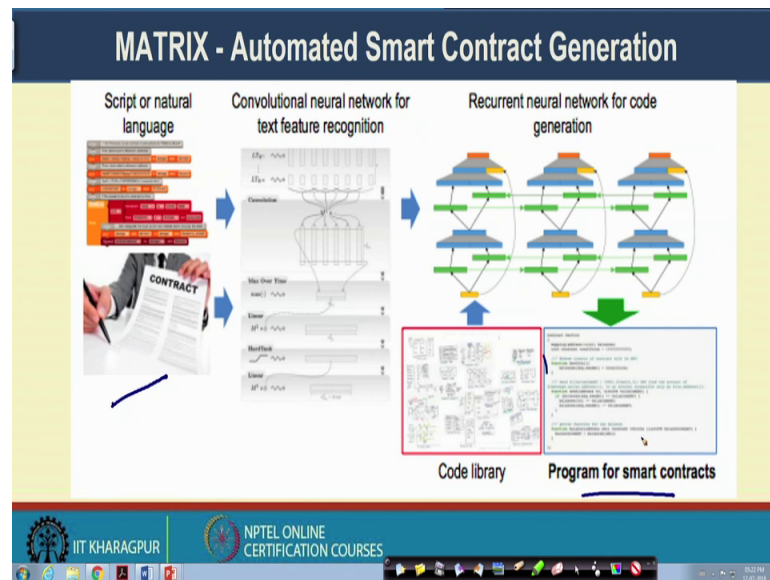
And the 4th and final requirement is to have a deep learning best platform for dynamic security verification. So, verification of the security features in the smart contract platform, ok.

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So, this is an interesting concept in matrix that matrix basically utilizes the proof of work and proof of stake altogether or a combination of proof of work and proof of stake to ensure consensus. So, the idea in matrix is something like that initially you do some random clustering based on proof of stake or some kind of other consensus protocol. And while you have this individual clusters, you take the route of this individual cluster and run proof of work mining on top of that. So, this is the combination of proof of stake and proof of work which has been utilized in matrix blockchain consensus protocol, ok.

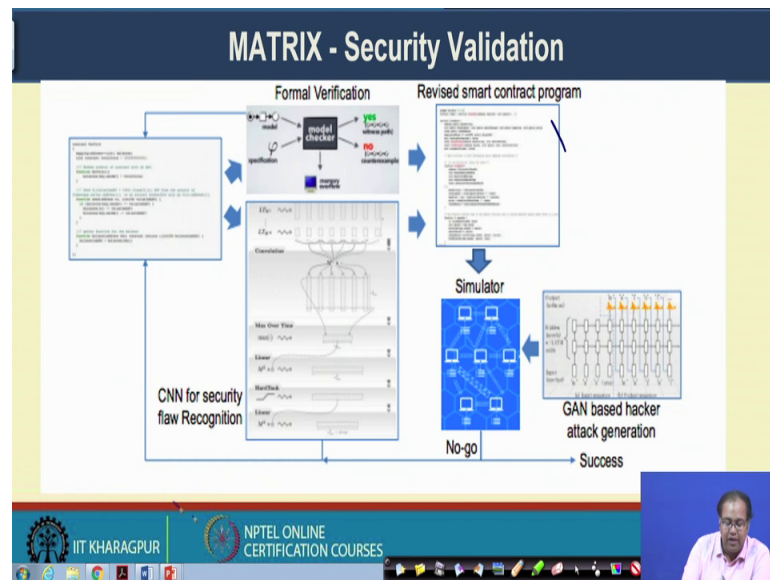
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Now, as I mention that matrix has a mechanism power automated smart contract generation. So, you are providing the contract in a script or natural language, then it uses artificial neural network tool boxes. The machine learning tool boxes like a convolution neural network for extracting the text features from this smart contract.

Then it applies a recurrent neural network for generating automatically generating the code from this text features. And finally, it generates the program for the smart contracts. So, this current neural network takes the text features and the code library and generates the final program for the smart contracts in matrix platform.

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Then the security validation in matrix you have a smart contracts. So, there are multiple ways of validating the security, you can have a formal verification by utilizing formal toolkits. You can have a convolution neural network for security flaw recognition within the court. And then you design a device smart contract by removing the security, put it in a simulator if the simulator runs it successfully, then you have a success and you can utilize the smart contract altogether, and in this simulator you are also providing attack generation module for different kind of attack which can come in the smart contract platform.

If this simulator fails to correctly execute the smart contract program, then again you do a formal verification and security flaw recognition on top of that. So, that way in periodic way on a recursive way you generate a correct smart contract from a given description of smart contract in natural languages. So, this keeps a broad overview of 4 different use cases of combining artificial intelligence and blockchain altogether. So, this gives a very powerful tool box; where you can run multiple intelligence decentralized secure applications altogether. So, I will request you to explore this 4 individual tool boxes in details, so many of them are open source or they have nice white papers, you can read those white papers to look into the fundamental design architecture of this individual platforms that I have mentioned.

So, thank you all for attending this class.