Computer Aided Decision System Industrial Practices using Big Analytics

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Lecture 31
BDA in IIOT, RR Engine Case Study

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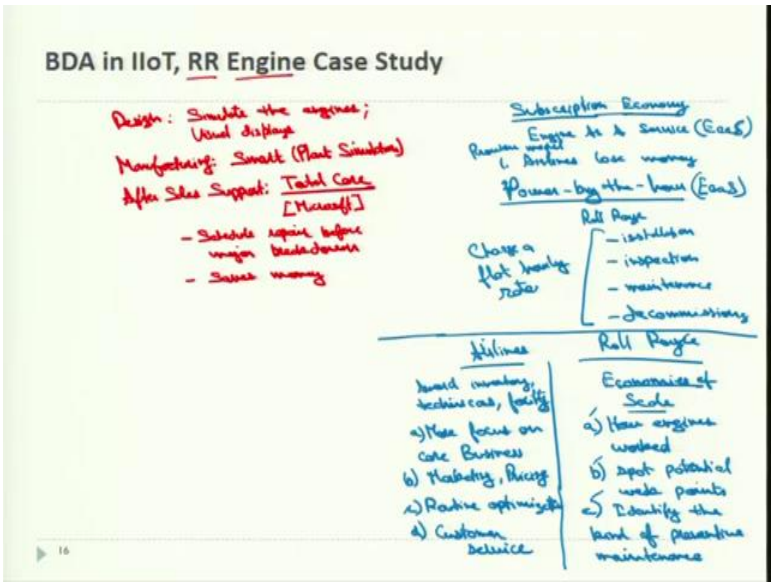

Welcome back to the course on Computer Aided Decision Support System, I will take a case study on manufacturing, in which Rolls Royce engine, which is now being provided as a service. How did this happen or how was this made possible through the internet or through the Industrial Internet of Things? The big data is creatively used by Rolls Royce, which is one of the leading producers of aircraft engines now.

To improve the design and production of its aircraft engine division, it uses algorithms to analyze large amounts of data, maybe terabytes of data to forecast when equipment will malfunction and to spot design flaws without ever having to create a prototype. They are also now going for the concept of digital twins, where it is a kind of Augmented Reality and Virtual Reality in which a similar model to the physical is developed in a digital platform.

So, whatever happens to the physical model, if some temperature rises there, the digital twin will also observe the same temperature rise. If some malfunction is there in the regular model in the physical model that would also be there in the digital model. How is this possible, because at each point or various layers of the actual equipment on the engine, maybe at the propulsion, maybe at the phase, maybe at different other points, the sensors are attached, which keeps on giving the information that is being recorded in the real time, this is a digital twin.

Now, Rolls Royce has majorly captured three streams.

1) 'Design' where Rolls Royce used sophisticated models to simulate engines, these models are also able to analyze sizable datasets and transform the outcomes into visual displays. So, they could have visual displays on the engine performance, by being able to simulate an engine's performance before it is actually built. So, engineers can save a significant amount of time and money not only Rolls Royce, most of the competitors have now started working on with this simulating the engine or the product simulation that I will also try to discuss to small extent in the coming lectures that how do CAD, Computer Aided Drawing, Computer Aided Manufacturing, Computer Aided Engineering helps us to simulate the product before even manufacturing it. There are platforms to have a mechanical or the thermal analysis done on them or simulation done on them. It could be console, it could be MCs, it could be maybe simple software such as Solid Works or so, which can help us to have these simulations run. So, Rolls Royce is already using this system.
2) Next is 'Manufacturing'. By connecting various manufacturing systems using the internet and enabling a seamless information transfer across the line, Rolls Royce is increasingly making its product line smart. Now, repair required machinery can communicate with plant engineers. That means the plant engineers do have tablets in their hands where they see what is a machine that is becoming a bottleneck, where is the product line being waiting or where is the stack of the material in the work in progress inventory. So, there could be a track, so smart manufacturing or maybe plant simulation could also happen. Parts can communicate errors early in the process when they are least expensive because they are tracked by the IIoT systems which are installed there. And, the engineers can move through the facility. So, while using big data in manufacturing and setting up a facility based on the Internet of Things, it is more practical when producing complex and valuable parts. When

I say complex and valuable parts, I am talking about the jet engines, which Rolls Royce manufactures.

3) Next is the 'Maintenance or after sale services'. So, Rolls Royce is trying to distinguish itself in the after sales support. This is a major concern or focus of the case study I am going to discuss today. After sales support, it is the maintenance of the engine that Rolls Royce has taken the complete responsibility of by employing a concept known as total care. What is this we will discuss? So, each and every Rolls Royce jet engine that is built has hundreds of sensors that produce enormous amounts of real time operational performance data, this data is sent to and stored in cloud through a partnership with Microsoft. Microsoft Azure data centers help them to store the data in the cloud.

- So, where these are analyzed using sophisticated algorithms designed to find the operational faults or operational anomalies that might indicate that aircraft need the maintenance, to schedule repair before something breaks down is the major target. It has the potential to prevent major catastrophe and save lives, because if the engine fails, definitely lives are at risk.
- So, it also saves a lot of money. So, that is why we call it a total care package where Rolls Royce is able to differentiate them from the general system.

- What is the model that they have? they call it subscription and it is Engine as a Service (EaaS model). By subscription economy I mean when customers pay monthly for a service, for example, per movie per serial pay per view, like Workday, or Sales force, Netflix and Spotify already provide assistance where you pay per view or in Spotify, you pay per song. So, these are kind of in a subscription economy where you subscribe to that and try to pay for specific views that you try to get from the product that you are handling. So, previously, what happened, airlines used to buy replacement engines from suppliers like Rolls Royce, this is I am talking about the late 1990s or so. They purchase the engines, install them and maintain them. The whole responsibility lies with the airliners only, the aircraft, not manufacturers, the aircraft owners, those who are running the airlines. So, here, there was a big challenge that they did not know how the engines work. But the engine manufacturers now have taken the responsibility of running and maintaining the engines. That is, what

they call is Engine as a Service. Here previously airliners lost in the previous model, that is the general model.

1) So, airliners lose money because of unanticipated engine failures, the lost flight revenue, the need to reschedule the standard passengers, the need for backup of aircraft or buffer engine inventory, or maybe having two engines at a time that is a general practice, which is called redundant engine. So, those were the points, which was consuming money. And also, they had to sometimes replace the jet engines too soon. And a variety of plane models in a typical fleet were required.
2) So, Rolls Royce understood this problem that airliners were facing and they came up with the model which they call as Engineering service or they call it Power-by-the-hour model. It is a subscription model, which is EaaS.

Rolls Royce would take care of

- installation,
- inspection,
- maintenance,
- decommissioning

And, they will charge a flat hourly rate which means from the airline's perspective, the predictability of the subscription payments as opposed to the big lump of the engine purchaser or overhauls was something that was highly appreciated by the finance department.

The airlines also enjoyed saving money by not having to pay for engine inventory. That is the repair facilities, repair engineers, technicians, the engine liability, the engine insurance or so. I would think it was taken care of by the Rolls Royce so deep.

The advantage the Rolls Royce had was the economies of scale, because airliners might have been having maybe 30 engines of Rolls Royce running in their aircraft company or so. Rolls Royce would have not 30, it would have 300 or 3000 engines of the similar kind that they are trying to maintain.

So, economies of scale were the advantage for the Rolls Royce. I would write,

- Airlines- Airlines could avoid inventory, technicians, the facility or the lab they have developed or these such payments.

a) The airliners could focus more on core business.
b) Core business means their air travel business, their core skill which may be including marketing, pricing. So, all the technical stuff for the engine is taken away from them.
c) So then, maybe, routine optimization where a different kind of analytics is there: the transportation analytics, the queuing models, the assignment models.
d) The customer service that they had to provide because they are directly dealing with the customers or the general public.

- Rolls Royce - Rolls Royce had an advantage of economies of scale. Since, Rolls Royce was now in charge of the overseeing of the lifecycle of hundreds and thousands of aircrafts, they had the resources to make significant investments in research on,

a) How engines worked
b) To spot potential weak points
c) The selection of or identify the kind of preventive maintenance.

This is where Industrial IoT plays the major role and this came into the play as a major or big player.

Now, to understand how the engine works, and where the maintenance is required, it has to have the information regarding how the airlines are running the business. So, what is the total fleet hours? What is the number of times the flight is taking that is known as wheels up and wheel down? So, all this data is to be captured by the Rolls Royce, for those different kinds of the devices are installed and airliners were happy to share the data because airliners also benefit while providing their data or their fleet or everything that it was required by the manufacturers or the Rolls Royce, so that airlines could also benefit financially from them.

So, this is how IIoT changed the overall scenario from a company who was just a sole manufacturer, to a company who would take care of the maintenance as well.

Let us compare this anomaly with the regular car services that you take. The car manufacturers have their service centers all around the city or so. To take your car for the routine maintenance, that is, for each maintenance, you pay them, they get a financial benefit out of it, or you do not

take you for in the routine, whatever the preventive maintenance schedule was, you do not take that, but then because preventive maintenance has not happened, the car would have a bigger failure, then you pay more for the replacement of the spare parts or so.

So, where do the car manufacturers benefit or do, they have more financial benefit, I would say in both of them. So, airlines have to go to Rolls Royce to get their engines maintained and have to provide the data and Industrial IoT system. Now, Rolls Royce is able to make a big market breakthrough using this. Digital twins are one of the technologies that Rolls Royce has also pioneered.

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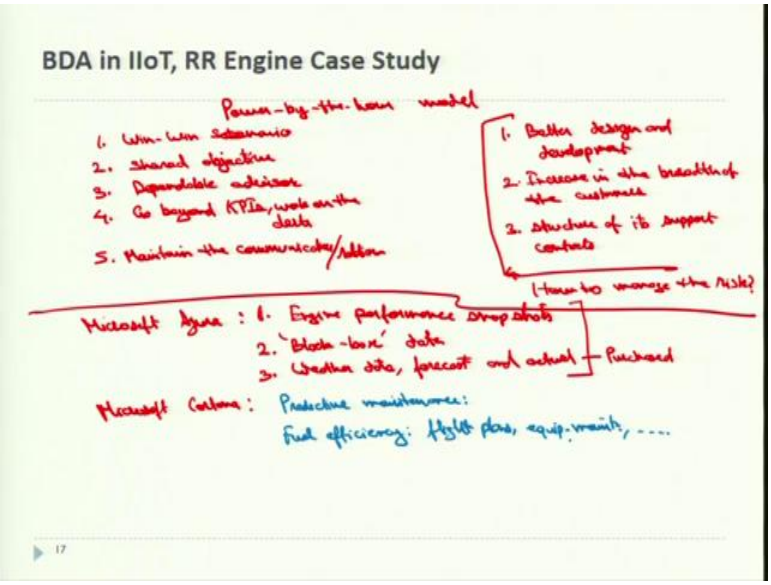

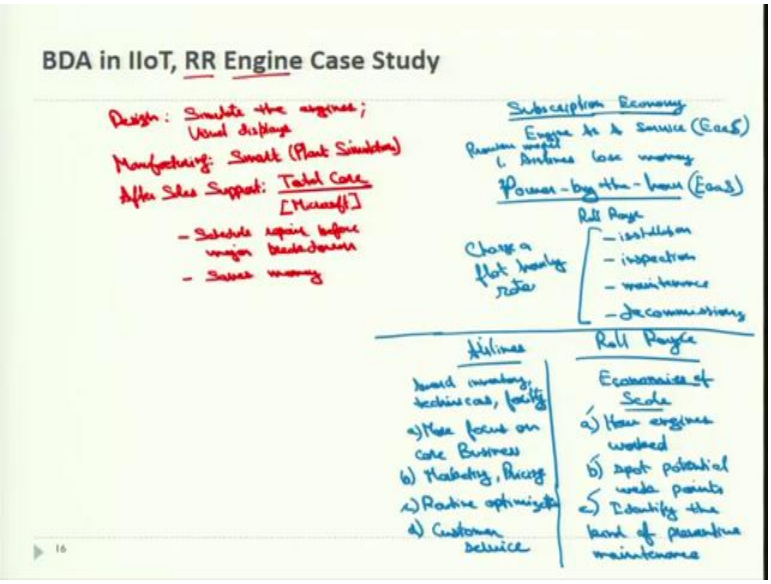

So, here the Power-by-the-hour is taken by Rolls Royce. So, when a customer understands that their vendor shares, their interest, and the situation is truly win-win, the very foundation of the relationship is altered, and when that occurs, we want our relationship or dealership to be more successful. So, we want to give them information about our engine performance, whatever they want, we will have to let them know and we will intend to drive to different places and try to let them know how the system is running. It is not just a payment schedule; it contains a better or greater customization and better alignment of how your customer business is changing and your services improving with time.

Keeping in mind the replacement of the general model with an engine as a service provider or power by the hour model. There were certain benefits, that is,

1) They were able to achieve a win-win scenario where the client perceives that you both stand to benefit and give strong advice.
2) Both of them had a shared objective to make the engine run efficiently to have the minimal maintenance cost or so.
3) they become a dependable adviser to each other.
4) They do not rely solely on the KPIs or the Key Performance Indices using IIoT; whatever the alerts are given by the sensors or so, they would also work with them in real time.
5) So, they go beyond key performance indicators and work on the alerts similar to those older radar detections. These alert functions were there. So, the radar detections were not very

effective previously. So, now, radar detections are more prominently used. So, this also maintained the communication between the client communication or I would say relation between the client and the manufacturer and which is gained through understanding their operations and rivals and seasonality or so.

According to the Microsoft case study on the Rolls Royce they said that Rolls Royce views the ability to offer a wide range of operational data as a way to increase the breadth of his customer services, because they would definitely be getting the benefit from the economies of scale and engines they were mentioning, they had an almost perfection in how to maintain in general, what kinds of the problems could occur in one kind of the airline, and they could project that to the other one. So, this was a big benefit. Number 1 is a win-win scenario for both of them. So, while reducing disruption and expense of maintenance, the ability to track and report the actual conditions of aircraft components could potentially result in significant savings. So, as per the Microsoft case study, the Rolls Royce business is also making progress, using analytics and machine learning to solve various other issues.

Another advantage that the company has, is better understanding of the requirements of the product development itself, if the maintenance schedule is such a way that they are getting reports from each of the maintenance of the engine, if the specific type of the issue is kept on repeating time, and again, maybe in the manufacturing itself on the design itself, they could be better developer of the engine only, this could also be one of the benefits that they have.

1) Better design and development. These were the additional benefits then what I have just mentioned here as the economies of scale or how engines work to spot potential weak points or so these were there operations were there tasks that they were to take. But better design and development from the information from the maintenance.
2) Increase in the breadth of the customers or clients.
3) Also, it was better able to understand the structure of its support contracts. Overall, I would say they were able to better understand how to manage the risk.

So, Rolls Royce provided a total care service solution. So, where they got the access to the real time engine data analysis for the engine maintenance and maximizing the aircraft availability. Now Rolls Royce implemented what platforms it used Microsoft Azure. This IoT suit they use to collect

aggregate data from various sources of data which were widely dispersed in order to meet the technological requirements of its initiative.

So, Microsoft lists the following as categories of data processed.

1) The engine performance snapshots.
2) Then, the second point is the black-box information. Black-box data I would say, which helps them to have the technical logs, the flight plans or so, how did it go, when did it planned or so.
3) Then, it had weather data as well. It is for both forecasts of the weather data and actual data. So, this gives a good picture or clearer picture of how Big Data Analytics or Industrial IoT can help the company to express its horizons in a different stream itself. it is a completely different tangent, the weather forecast, actual forecast and the forecast that was scheduled or so, that was put into picture a day before.

So, this study is also important for a company which is a core manufacturing company, engine manufacturers. So, this is also one of the important aspects that we can see, that how things are being connected here. So, this was supplied by outside sources, this was data which was purchased weather forecast and everything.

So, in order to accurately identify operational anomalies and assist clients in planning pertinent actions, the company also used Microsoft Cortana. So, this helped the analysts to analyze the datasets and carry out the modeling at a scale. Two major analytics were taken on,

1) Predictive maintenance, that is, for instance, if a fuel pump is to be taken for the preventive maintenance or so, how frequently it has a soft line based on how long it has introduced, at what point it is advised to remove the fuel pump or actually maintenance or so. So, these kinds of decisions are supported by Big Data Analytics. So, it is possible to provide an alert that suggests a specific pump may not be performing well and should be replaced sooner than it was scheduled, because it is a soft line by analyzing the detailed data from each individual pump, and comparing it to the data models for other pumps in the future or so. So, this was one predictive I would say maintenance, which is sensor-based maintenance only.

2) Fuel efficiency data if I say the company was able to assist the airlines is understanding precisely which elements such as, flight plans, equipment maintenance, weather or discretionary fuel, which have a greater impact or greatest impact on the fuel performance by comparing it with existing forecasts or reference tables or historical data or so. So, they can have, they can take charge or they can have the information of what time the flight is in the air and what is the frequency that is wheels up and down as I said, so, it is all information that could be collected.

So, this was a case study that Rolls Royce took on their engine and they provide the model power-by-the-hour. So, I will continue in the next week and we will discuss more on Big Data Analytics in the present scenario, in the Industrial Internet of Things, in additive manufacturing, or maybe Computer Aided Design or so, how does that help, thank you.