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Prognosis for connected cars

Introduction:

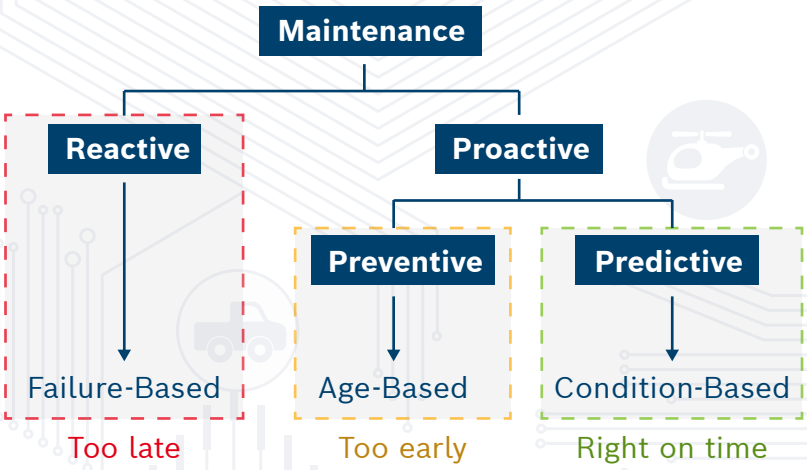
Industry 4.0 is transforming vehicles into computers on wheels [1] .Remarkable advancement in the field of connectivity has enabled improved vehicle to vehicle communication, generating sufficiently rich volume of data. This has created opportunities for the development of smart machines that are capable of increased automation, self-monitoring and predictive diagnosis or prognosis of potential fault without human intervention.
Traditional IT systems empowered with rich data from the array of sensors from connected cars along with cutting-edge Machine-Learning (ML) algorithms can contribute significantly to ensure efficient functioning of automobiles through self-monitoring and prognosis. This also greatly helps to optimize maintenance schedule, leading to higher customer satisfaction and reduced costs.

With the global market for connected cars expected to grow by 270 percent by 2022 and with more than 125 million passenger cars with embedded connectivity forecast to be shipped worldwide between 2018 and 2022[2] , this is the right time to build Advanced Prognosis as an integral part of connected transportation.

Prognosis Overview:

Need for prognosis:

Vehicle uptime is getting increasingly crucial as the transport solutions become more complex and the transport industry seeks new ways of providing affordable transport solutions. Traditional Fleet Management systems are gradually being enhanced with new features such as better maintenance planning to improve overall reliability. However, these traditional approaches for maintenance i.e. corrective and preventive approach is sub optimal when it comes to delivering uptime and efficiency. This is where the technology of providing predictive maintenance via unsupervised and supervised ML methods can genuinely change the game. These systems are capable of predicting the need for vehicle maintenance or a plausible failure of a critical component such as. Battery, Brake, Starter Motor, tires, etc. which are essential causes of vehicle downtime. The methods are entirely data-driven and use extensive amounts of data, either streamed on-board data or historical and aggregated data from off-board databases. Predictive maintenance takes on-board diagnostics, which only diagnose existing conditions, one step further by predicting and thereby preventing the occurrence of future failures.

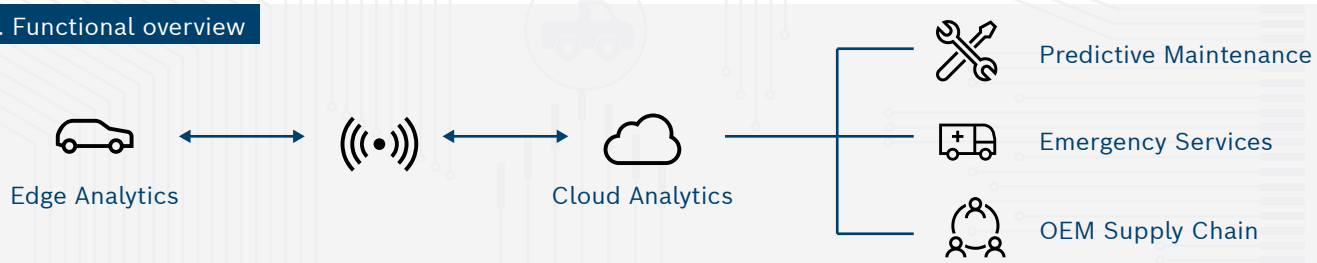


Analysis of Connected car data:

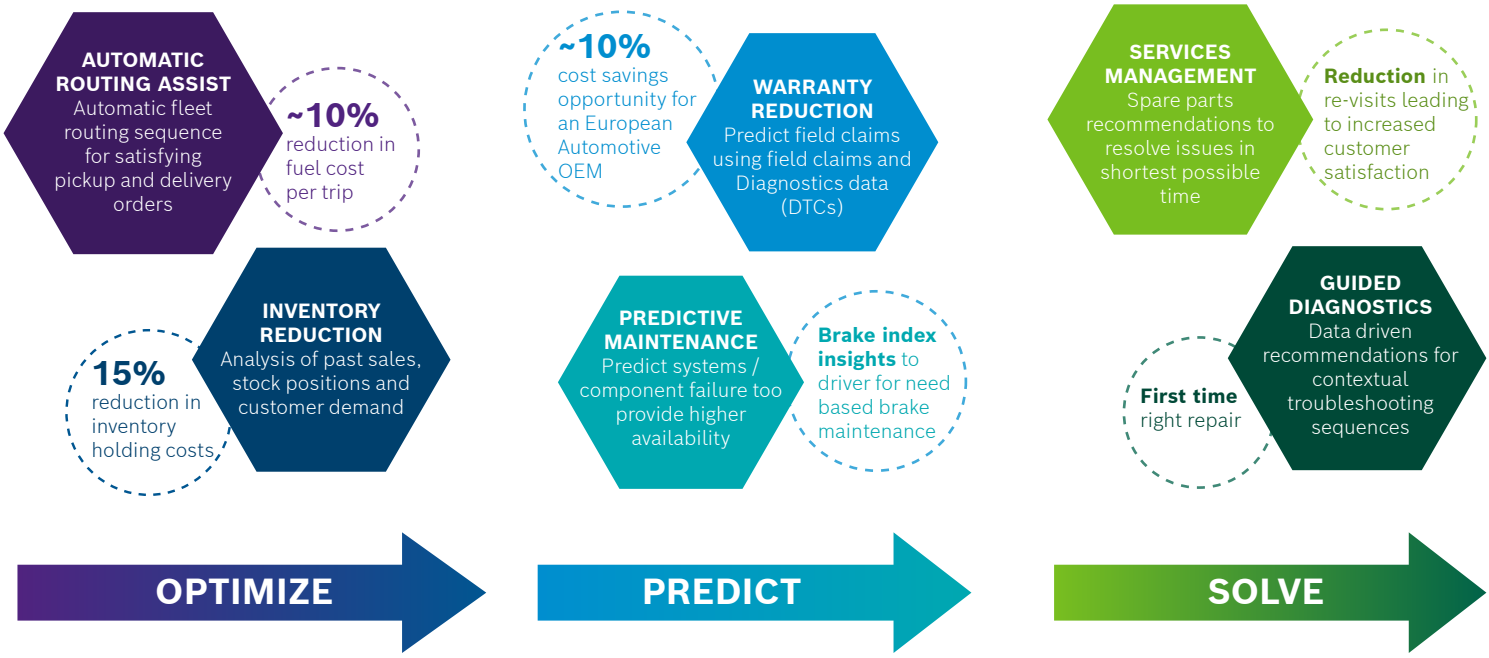
According to a recent Intel Corporation report, an autonomous car generates approximately 4TB of data per day [3]. Needless to say, a connected car that is equipped with multiple sensors along the powertrain and infotainment systems will generate substantially high amount of data as well. Even though it is a great challenge to manage this high volume of data, it is the availability of this data that is critical in carrying out prognosis of key components [4]. Intelligently designed data streaming methodologies and an efficient split of edge and cloud computing can reduce the load on the desired cloud infrastructure and will ensure a smooth end-user experience and reduced cloud subscription cost for the OEMs.

Efficient handling of connected vehicle data for prognosis can be attained by significant optimization of data volume through feature engineering, event based transmission and edge-cloud job split up. Data residing on the cloud is consumed by multiple ML algorithms for continuous learning that helps in predicting component criticality and prompting the end user to make key decisions at the right moment.

Fig. Functional overview



Benefits for cloud-based prognosis for connected cars:



Generic Overview:

To summarize, predictive diagnosis for connected vehicles can provide a variety of benefits for all the stakeholders involved in connected transportation. The critical advantages that are listed below provide an overview of the benefits which the adoption of prognosis will provide.

1. Smart utilization of rich data from the vehicle sensors

2. Reduced downtime, a vital requirement for efficient fleet management

3. ML based prognosis algorithms instead of traditional rule based paradigm ,leading to increased automation and continuous learning reducing the need for frequent human calibration

4. Reduction in vehicle maintenance cost for end users and warranty cost optimization for the OEMs

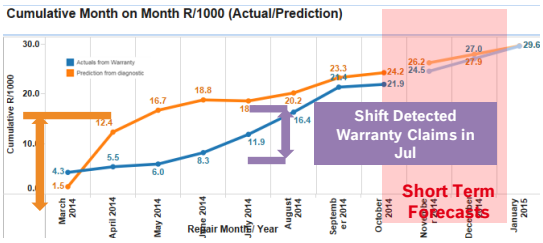
5. Efficiently designed cloud-based architecture ensuring smooth scalability and seamless onboarding of new vehicles or OEMs

Overview of our connected vehicle implementations:

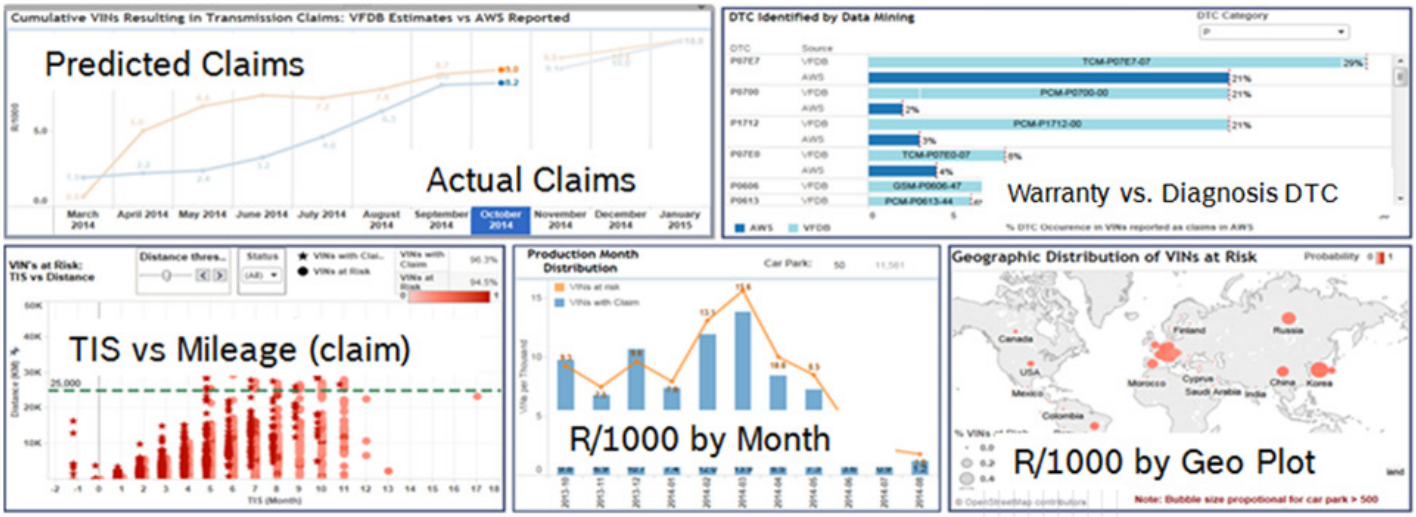
Multiple solutions centered on connected vehicle data and diagnostic data which we have implemented are already enabling customers with significant edge in decision making and cost reduction.

1. Early Warning System: Vehicle telematics data coupled with warranty claim data helped to create intelligent early warning and recommender systems ensuring reduced warranty cost and efficient fleet maintenance.

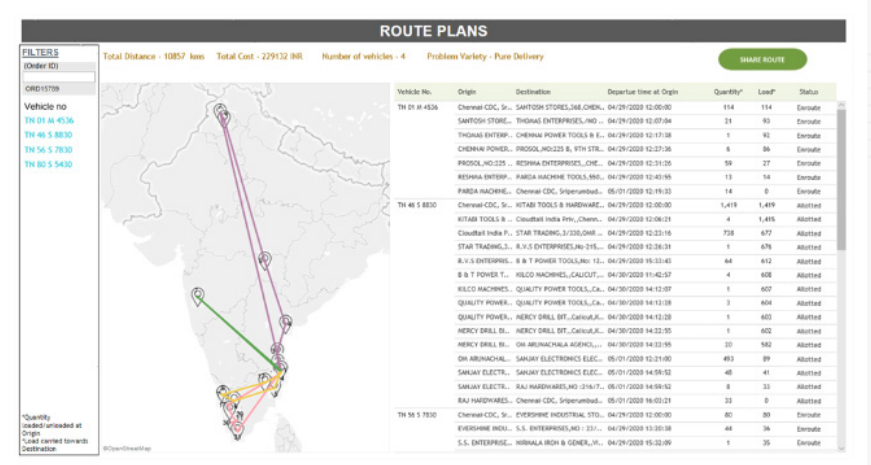
The system achieved a 7% reduction in annual warranty costs and prediction of field failures at least 2 months prior to occurrence

Data		Methodology	Results
Field Diagnostics Data	▸ 43k global VIN sessions ▸ Diagnostics trouble codes ▸ Data identifier ▸ Module, Fault type	▸ Algorithmic ETL ▸ Association Mining ▸ Graph clustering ▸ Page ranking ▸ Similarity measures	
Other Data Sources	▸ Vehicle Diagnostic data ▸ Hotline support ▸ Warranty claims ▸ Manufacturing data ▸ Technician's comments ▸ Roadside Assist		DTC = Diagnostics Trouble Code VIN = Vehicle Identification Number DID = Data Identifier

▸ Development of early warning system to detect quality issues using vehicle diagnostic information
▸ Identification of VINs with risk of failure

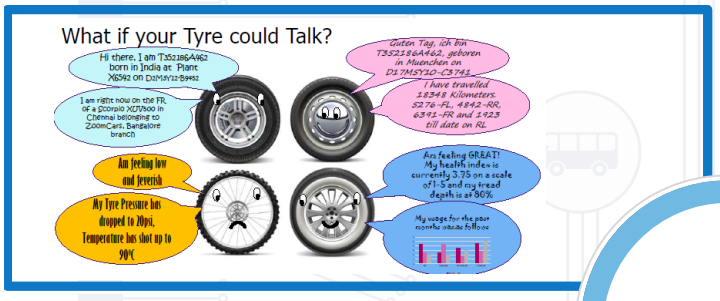


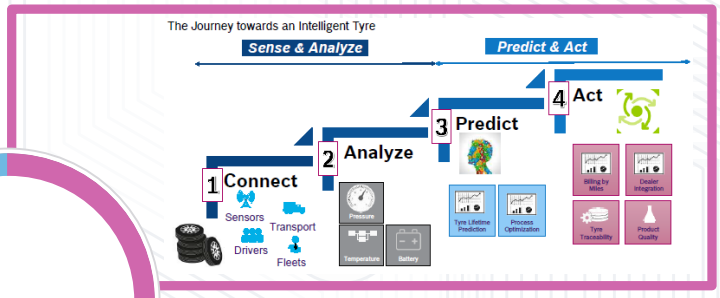
2. Vehicle Routing: Automatic vehicle routing developed from vehicle GPS information and complex optimization heuristics facilitated smooth operation across the supply chain and delivered reduction in fuel cost and thus reduced vehicle emissions contributing to a cleaner environment.



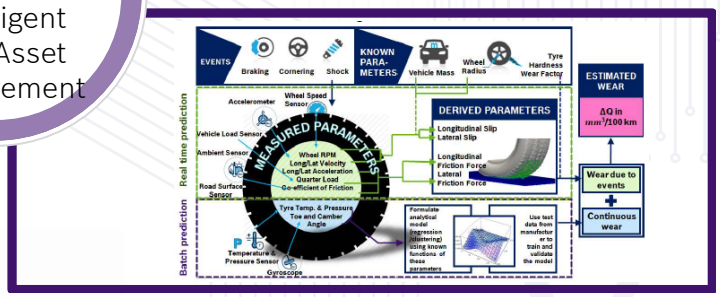
3. Smart Tyres: For commercial vehicles, undergoing extensive drive cycles across highways, it is necessary for OEMs to ensure smooth drivability. Tyres being one of the critical components undergoing significant amount of stress and strain and therefore it is necessary to monitor and predict their health status constantly. Our smart tyre solution is capable of providing an advance alert to end users or a service center ensuring that prompt action is taken when requirement is identified.

Intelligent Tyre Asset Management





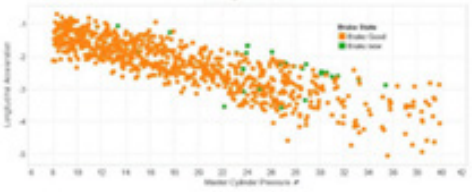
Intelligent Tyre Asset Management

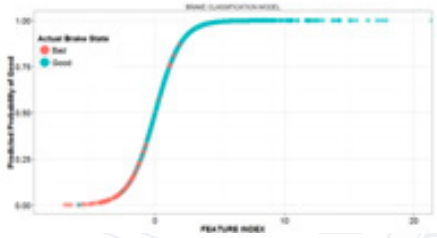


4. Predictive Maintenance for vehicle components-Brakes: The Braking system is one of the most important operation and safety components for vehicles. Predictive diagnosis for brakes provides advance warning for potential wear-out of various parts in the braking system. Sensor data from wheels and other associated systems are fed into sophisticated ML models, which predict the state of the braking system as a whole.

DATA RESOURCES	FEATURE EXTRACTION	MODELING
ABS Signals: 40 Measurements	184 Features	49 Weighted Features

- Vehicle Sensor Data
- Sensor Data @ Wheel
- Brake Flags
- ABS Control
- Road information





- 100% accuracy in classifying good brakes with the multi braking cycle
- High accuracy in predicting bad brakes with brake efficiency loss greater than 30%
- Potential revenue generation of USD 5m over a period of 5 years if added as a value added function in ECU

Conclusions:

In conclusion, it can be said that in the present era,connected vehicle data is the most essential asset across the automotive industry and it is the need of the hour to utilize the data to its full potential. The utility of this massive amount of data can be extended beyond the reactive maintainance or diagnosis to predictive maintainence which leads to higher efficiency and remarkably high customer satisfaction. Bosch data science practices, empowered with in-depth knowledge of automotive systems and proven capabilities in delivering cutting edge solutions on connected vehicle data,as well as solutions centered around autonomous driving and personilaztions involving new age technologies like computer vision and Natural Language processing (NLP), brings the perfect balance of expertise for development and deployment of sophisticated solutions around this massive data and thereby helping their customer OEMS to stay ahead among their peers.

References

[1]. "A Scalable and Reactive Big Data Architecture Design for Predictive Maintenance of Connected Cars". http://www.digitalxplore.org/up_proc/pdf/493-15936697841-5.pdf

[2]. "Connected cars report: 125 million vehicles by 2022, 5G coming | Internet of Business." [Online]. Available: https://internetofbusiness.com/worldwide-connected-car-market-to-top-125-million-by-2022/.

[3] Brian Krzanich " Data is the New Oil in the Future of Automated Driving" Intel newsroom 15-Nov-2016. [Online].Available: https://newsroom.intel.com/editorials/krzanich-the-future-of-automated-driving/#gs.9brmwy

[4] K. Dodson, "Connected Car -The Driven Hour," Cisco Blogs, 18-Feb-2019. [Online]. Available: https://blogs.cisco.com/sp/connected-car-the-driven-hour.