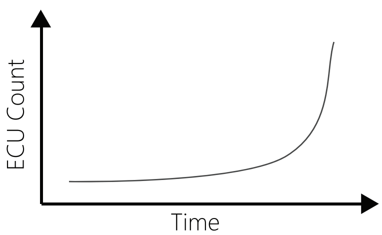
Reducing Vehicle Down-time through Guided Diagnostics

The case for guided diagnostics

We live and work in a world where our demands for safety, efficiency and comfort are driving the development of ever-increasingly complex vehicles and vehicle architectures. You only need to look at the [exponentially growing] average number of ECUs in a modern vehicle to see evidence of the real challenges faced today. ECU count is just one example, but this alone is a great example of complex growth – how do you manage so many modules? Are multiple networks required? What are the increased material costs of adding ECUs (extra wire, fitments, etc.).



The electrification of vehicles and autonomous concerns adds yet another extra layer of complexity on top of the vehicles of today.

When we look at modern engineering approaches, such as feature-based architectures, virtual ECUs, etc. the complexity of diagnostics or diagnosing a defect and locating its root cause become exponentially more complex.

The ramifications of this complexity are clearly seen when we look at the groups that must manage and update these vehicle technologies (such as manufacturing end of line or OEM after sales dealers). This is especially focussed in the after-sales service environment, at the interface with the customer. The customer experience is critical to building and maintaining brand loyalty; it is vitally important that any vehicle downtime is kept to a minimum.

This is in direct contradiction to the increasing demands of customers and the desire to reduce vehicle downtime. Traditionally, the technician or perhaps even the master technician has held the knowledge that enables effective repair of the vehicle. In complex environments, however, the ability of that same technician; even with all his knowledge is limited. Ultimately this reduces the effective diagnose and thus repair the vehicle in his care.

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A further frustration with modern vehicles is the increasing occurrence of replacement of non-faulty parts. This is commonly referred to as 'No Fault Found' or 'No Trouble Found'. It is the outcome of a technician replacing a part that was in-fact not the root cause of the customer-reported issue. Generally, this will require the customer to return to the dealership, and almost certainly will cause inconvenience that could have been avoided. If the vehicle is under manufacturer warranty, there is a direct cost to the OEM.

What can be done to solve the problem?

The pain-points are obvious – high warranty costs, low customer satisfaction, etc. and they are all ultimately caused by misdiagnosis. Such pain-points can only be mitigated or resolved if effective diagnoses are performed.

Regrettably, the bottleneck to effective diagnosis is the technician. Increasing complexity requires increased knowledge, skill and experience – all of which come at a cost (direct or indirect). It is impossible to train all technicians to master or equivalent level, but the complexity of modern vehicles paradoxically requires an ever-skilled resource to carry out an accurate (and thus effective) diagnosis.

One approach is to reduce the reliance on a technician's decisions and to introduce the concept of guided diagnostics.

What is guided diagnostics?

Fundamentally guided diagnostics is the process of diagnosing a root-cause fault on a vehicle by starting with a fault scenario (for example certain symptoms, and perhaps other evidence) and directing the technician through several tests that lead to a conclusion on the causal component.

The evolution of guided diagnostics

Guided diagnostics have evolved over the years. There are different methods and different methodologies forming a guided diagnostic.

- Step-by-step diagnostics - The simplest form of a guided diagnostic can be visualised as a flow of simple, procedural steps; that if followed will (potentially) lead to a correct diagnosis of mechanical faults.
- DTC-based diagnostics – Where an electrical system is involved, the DTC-based diagnosis allows a technician to perform tests based on the DTCs present. This can be a long, laborious process, and is reliant on the accuracy and abundance of information relating to the DTC(s).
- Model based diagnostics – A mathematical model is used to represent the engineered systems.
- Network-based guided diagnostics – This concept encapsulates the idea that models are built to represent the digital twin of the vehicle, and information from the real vehicle could be fed into the model, providing a far more accurate picture thus informing the diagnostic steps to take in a dynamic, continually adjusting fashion.

Why network-based diagnostics?

The fundamental benefit of advanced techniques such as model and network-based diagnostics is the transition from static to dynamic diagnosis.

Static diagnosis relies on a large amount of pre-determined information, and can only be as accurate as the information that it built from. This is perfectly functional if the fault is known or understood, but it assumes that certain conditions hold.

Dynamic diagnosis, however, uses a model that is continually adjusted. The facts that are fed to the model are continually updated as more information is understood, or certain conditions met or ruled out.

Validation and Continual Improvement

The key differentiators of such a system is its ability to leverage vehicle engineering data and improve over time. This is especially true for dynamic, data-driven diagnosis systems. Equally as important, however, is the ability to trust in the quality of the data within the model. Take, for example, the need to ensure that – for a given vehicle – as much as possible that there are viable root-causes for parts.
A dynamic system has an inherent advantage in these scenarios. The power of the K-Grip reasoning engine allows clever algorithms to be developed that can detect simple gaps that would have otherwise been missed and perhaps never discovered. For example:

- Orphaned Parts – A part exists in the model but it has no connection. This means that any fault scenario (for example symptoms related to the part, or DTCs) which would otherwise end with a root-cause, would not be diagnosed. This will lead to no fault found outcomes, and will clearly impact customer satisfaction.

- Incomplete Faults – One or more fault scenarios (for example, specific symptoms) are not complete. This is generally defined as a path through the engine that does not lead to a root-cause.

Data Capture and Storage

For a typical OEM thousands upon thousands of vehicles are diagnosed every day. It is vital that this data is captured, as it is invaluable in both validation of current model links, and learning of new and un-related links.

A typical (by simplified) data capture process can be seen in Figure 1. Local clients capture data, and store diagnostic sessions. These are then asynchronously fed to a remote storage system that captures and manages the data. The session tracking engine can be optimised to handle online/offline scenarios and track multiple local clients transparently.

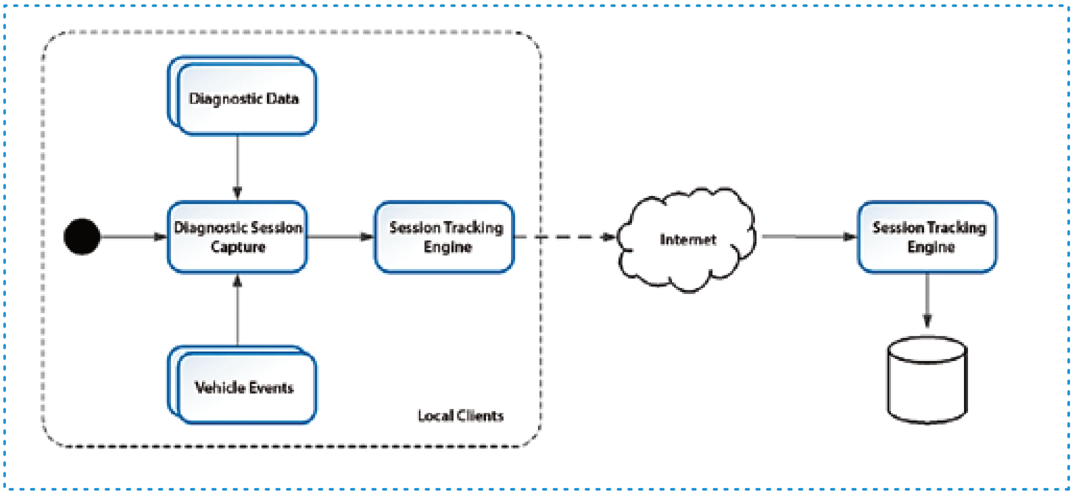

Figure 1 Session Capture and Storage

Data Volume

The volume of data collected is significant. The pictographic below shows the volume of data that would be collected if all diagnostic sessions for a typical medium-large OEM.

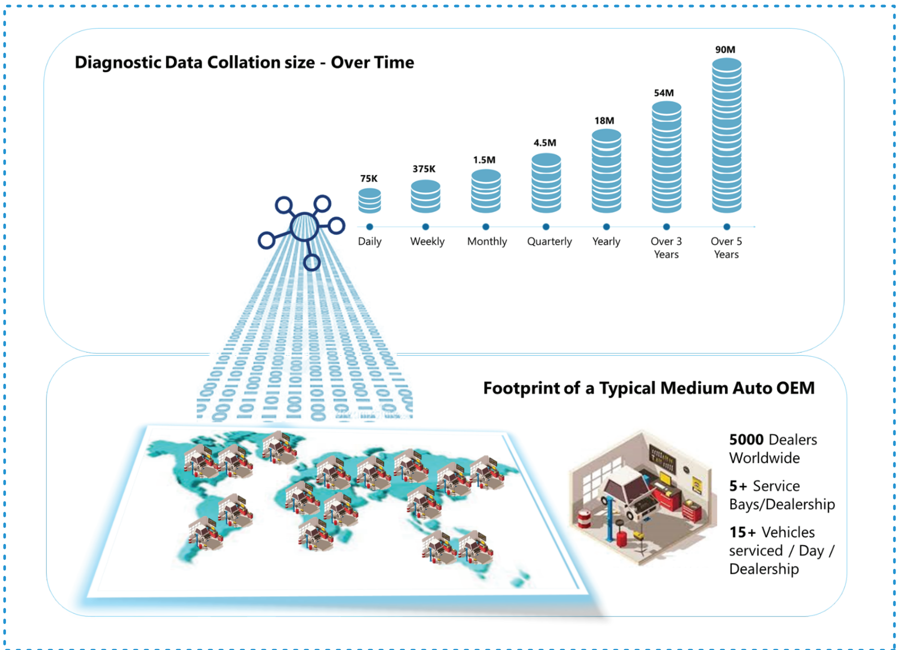

Figure 2- Diagnostic data volumes

With so much data, it is important that the format is easy to interpret, and well keyed. This allows for offline processors to crawl the data space and extract facts that can then be used for further analytics.

The "learning loop"

The concept of the learning loop is enabled by the large amount of data that the system gathers. Take for example, a scenario where suddenly, an increasing number of components are being replaced, but with no fault found. With the data present in the system, it is possible to spot clusters of failures that are not expected – and alert the system engineers to issues early. It is then possible to isolate the cause, and update the model to provide an alternative test that directs the technician to check the 'actual' causal component, removing the no-fault-found situation.

K-GRIP as the solution

KGRIP is KPIT's model-based diagnostics solution. It's ground-up scalable architecture, combined with state-of-the-art reasoning engine make KGRIP the ideal solution.

Benefits of Validation

One of the fundamental checkpoints of any diagnostic system is: how effective am I?
Some questions that need to be asked are:

- Does my system have diagnostic steps for each root cause? I.e. can I perform a diagnosis for each component in the system.
- Does my system have symptoms assigned to each root cause i.e. can I describe the problem that presents for every component?
- Are there any components with no root cause?

The K-GRIP solution provides tools to significantly lower the overhead of validating these questions. The solution provides tooling and reports that allow an engineer to inspect the model and quickly determine any breakages, and their associated fixes.

Conclusion

To summarise the ever-increasing diagnostic needs of modern vehicles will drive innovation in many areas. The complexity may eventually reduce as modern solutions to traditional problems evolve the technological make-up of a vehicle, but there will always be a need for effective diagnosis and thus a system that can provide effective tools to end-users – the technicians.

KPIT has products and services that meet and exceed the demands of the increasingly complex diagnosis.

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About KPIT

KPIT (BSE:532400; NSE: KPIT) is a global technology company focused on providing technology solutions and expertise to the Automotive & Transportation Industry. KPIT is at the forefront of automotive engineering globally with solutions in the areas of Autonomous Driving, Connected Mobility, Vehicle Electrification, AUTOSAR & In-Vehicle Networks and Vehicle Diagnostics. Together with its customers and partners, KPIT creates and delivers technologies to enable creating a cleaner, greener and more intelligent world that is sustainable and efficient.

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