Increasing Complexity of Software in Automotive Industry

Mr. Ashish Khushu
VP & Business Unit Head | Transportation

April 26, 2016
Tata Elxsi | An Introduction

Design, Engineering and Solutions Focus

• Established in 1989, Independent public company, listed on NSE and BSE
• Integrated capability for software, hardware and systems - over 25 years of experience
• ‘Consumer Insights’ led design and UX – studios in London, Bangalore, Pune
• IP and solution accelerators, automation tools and process frameworks to enable customers

Right Scale + Relevant Experience

• 5000+ engineers and growing
• Experience in aligned industry verticals – CE, Broadcast, Communications, Medical
• Flexible engagement models – ODC, CoE, Program based, Fixed Bid, T&M, SA

Assured offshore capability and processes

• Over 80% of projects completely delivered through offshore engineering teams
• ASPICE and SEI CMMi Level 5 certified processes
• Consulting & deployment of DevOps, Agile, Cloud Development Environments

Financial Stability and Performance

• $1B market cap, zero debt, large reserves
• Growth leader for Product Engineering Services
• TATA backing and financial strength
Services & Industry Verticals

Technology consulting, R&D, Product Engineering, System Integration and Testing + licensable software components & IP to enable time-to-market

<table>
<thead>
<tr>
<th>Consumer Electronics</th>
<th>Automotive</th>
<th>Communications</th>
<th>Medical Electronics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smart TVs &amp; Gateways, Smart Phones, Tablets, Consumer AV equipment, Broadcast devices and interactive applications</td>
<td>3G and 4G wireless, Unified Communications, Internet Of Things (IOT), WiFi, Bluetooth, IP based voice and video</td>
<td>Infotainment, Telematics, ADAS, Safety &amp; Security, Body, Chassis, Hybrids and Powertrain</td>
<td>Wearable devices, Imaging and Graphics, Mobility, Compliance</td>
</tr>
</tbody>
</table>

Product Design & UI
- Mechanical Packaging, HMI and User Experience

Application Software
- Middleware, protocol stacks, applications

System Software
- BSP, Drivers and Firmware, OS porting and optimization

Silicon & Hardware
- SoC development, custom board and hardware design
Key Stories from CES 2016

- Toyota brings connected vehicle services to mainstream with its own big data centre and SmartDeviceLink
- Mercedes-Benz “It’s all about me” user experience
- Audi is fully connected, piloted and electrified
- Bosch to offer retrofitted eCall solution
- Subaru names Magellan as Cloud navigation partner
- VW shows BUDD-e van and e-Golf with connectivity
- Visteon develops cockpit ECU controller for carmaker
- Panasonic unveils in-car content delivery platform
- BMW shows AirTouch contactless touchscreen
- Nissan Europe selects Microsoft Azure for telematics system
- Harman: Connected services, drones, ADAS, active safety, Office 365 and Life-Enhancing Intelligent Vehicle Solution (LIVS)
- Magna teases affordable Level 2 autonomous technology in Cadillac ATS concept
- Subaru adds Liberty Mutual’s UBI app RightTrack to StarLink infotainment system
- QNX releases new software platforms for ADAS, automated driving and in-car acoustics
- Faraday Future reveals 1000HP intelligent electric concept car FFZERO1
- FCA’s 4th generation UConnect infotainment supports CarPlay and Android Auto
- AT&T expands 4G/LTE connected car agreement with Ford & BMW in Americas
- Kia’s sub-brand DRIVE WISE will work on intelligent autonomous vehicles
- Ford revs up development of autonomous vehicles, home automation and smart mobility
- Volvo and Ericsson collaborate to bring streaming content for autonomous cars
- Nuance powers BMW’s conversational in-car infotainment system with Dragon Drive
Key Automotive Industry Trends

• Connected Car
  • Connected Infotainment
  • Telematics
  • Apps

• Automation of Vehicle Functions
  • DAS
  • AEB
  • Steer By Wire

• Efficiencies
  • Lightweight
  • EV/HEV
  • Fuel Alternatives
The “digital” car

Fighter planes : 20 M lines of code
High end cars : 100 M lines of code
Electronics SW : < 20% of car cost in 2005
Electronics SW : Almost 40% today
Innovation Spend : 90% in Electronic Systems
Spend on innovation : US$ 105 B in 2014, 4% of revenue
SOC market : USD 31B, 7.5% growth

OEMs increasing Model choices but decreasing number of Vehicle Architectures
## Connected Car trends

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Cars</th>
<th>Connected Cars</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>1.05 B</td>
<td>8%</td>
</tr>
<tr>
<td>2015</td>
<td>1.09 B</td>
<td>10%</td>
</tr>
<tr>
<td>2017</td>
<td>1.18 B</td>
<td>14%</td>
</tr>
<tr>
<td>2020</td>
<td>1.32 B</td>
<td>20%</td>
</tr>
</tbody>
</table>
Connected Car - Convergence of Technologies

Telematics
- Turn – By – Turn Navigation
- Road Side Assistance
- Location Based Services

Remote Services
- Stolen Vehicle Detection
- Vehicle Health Report
- Geo Fencing
- Diagnostics

ADAS

Rear Seat Entertainment
- Smart Phone Integration
- Security
- Location Based Services

Connectivity
- 3G, 4G
- Car as a Hotspot
- OTA Updates

Connected Infotainment
- Content on the go
- Hands Free Calling / Bluetooth/Voice/Gesture

Auto Industry capabilities
Non Auto capabilities
Challenges: "Clock Speed" delta between Car & CE

A Typical Program Schedule

<table>
<thead>
<tr>
<th>RFQ/Specs</th>
<th>Development</th>
<th>Production</th>
</tr>
</thead>
<tbody>
<tr>
<td>½-1 year</td>
<td>2-3 years</td>
<td>3-5 years</td>
</tr>
</tbody>
</table>

2010

But In 3 years,
Look how things change in the CE world...

Vehicle development cycles are 3-4 years vs. typical consumer electronics development times of 18 months (or significantly less)

As a result of this dynamic, 85% of consumers would be willing to pay an additional $150 just to have the option to upgrade their vehicle electronics.

RAM
- Car: 300%
- CE: 100%

CPU Speed
- Car: 130%
- CE: 150%

Display Resolution
- Car: 100%
- CE: 150%

RAM
- Car: 300%
- CE: 100%

CPU Speed
- Car: 140%
- CE: 300%

Display Resolution
- Car: 150%
- CE: 300%

Mobile Data Speed
- Car: 250%

Connected Car Adoption

Growing Consumer Demands

Connected Car

Regulations

OEM
Connected Car Architecture

External systems and networks support new services and interactions ... and increase risk.

Radio Data System (RDS)

Electric Chargers

V2I/2V

Ad-Hock Network

Mobile Devices

OEM Dealerships (e.g. Repair Shop)

Local Service

Public Network

Toll Collection Systems

Road Side Unit (RSU)

Local Service

OEM Data Center

Internet Backbone

ISP BS

ISP BS

ISP

ISP

3rd Party Application Center

GPS

ISPs

BS

BS

3rd Party Application Center

Copyright © 2016 Tata Elxsi | Confidential | 11
No gateway, so all sensors directly connect into the cloud.
Connected Car Architecture

No gateway, so all sensors directly connect into the cloud

What about the database? Do we want a single storage?

Make Edge servers as near as possible to the sensor. Make them region based.

If a vehicle moves from one region to another do we want to make the data transmitted to the nearest server?

Dynamic switching of sensor data connection

Device data collector (Europe)

Device data collector (London)

Application

DB

DB
Data Volume: 50GB+/per hour/per car

- Data accuracy vs data size
  - Eg., collect GPS data of vehicle
    - Latitude (8) + Longitude (8) + number of satellites (4) + direction (4) + altitude (4) = 28 bytes per collection per vehicle
  - Collect every 5s
    - 12 points every minute = 28 * 12 * 60 * 24 = 483,840 per day
    - i.e., 14, 515, 200 = approximately 15MB per month per vehicle
  - Collect every 1s
    - 60 points every minute = 28 * 60 * 60 * 24 = 2,419,200 per day
    - i.e., 72, 576, 000 = approximately 72MB per month per vehicle
  - Data size increased 4.8 times when we increase frequency
  - But accuracy is lost when we reduce frequency

- Accuracy required depends on data
  - Eg., For Vehicle tracking system,
    - If real-time route tracking is a requirement, location needs to be collected at a high frequency in seconds
    - While velocity of the vehicle can be tracked at a frequency of minutes maybe every 5 minutes

- Trade-off between accuracy and volume
Database Choice: The Data Type

• Is Data geospatial?
  • For eg., Vehicle Management
    • Location of vehicles is location based
    • Need to know relations of vehicles w.r.t each other
  • Need geospatial representation of data
  • Geospatial query of data

• Is Data temporal in nature?
  • For Vehicle Management
    • Where was the vehicle at 12:00 and where is it now?
  • Need time-series databases

• Need both in the same database
Data Volume impact on Architecture

Should the data be replicated in all the servers?

Store raw data in regional servers

Store processed data accessible to the application

Device data collector (Europe)

Device data collector (London)

DB

DB

Analytics

Application
Or the other approach

Load distributed across multiple servers

Device data collector (Europe) → DB → Analytics

Device data collector (London) → DB → Analytics

Should the output of the analytics go into the same database?

Go the cloud directly?

Store into a new database locally
Database Choice: Data ingestion rate

Machine-scale data ingestion, indexing and storage
Too large to fit into memory, hence cannot be a memory based DB
Reduced latency in queries on the ingested data
Database Choices

ParStream
BlinkDB
InfoBright

BlinkDB and InfoBright provide approximate queries
- Improves speed, but introduces more noise over a noisy data
- How much noise can you tolerate in data?

MongoDB (Allows for geo-spatial queries)
SpaceCurve (Spatial organization of data)
DataStax (Cassandra for IoT)
OpenTSDB (Time series)

Relational DB?
Do you want to do Offline Analytics
Hadoop/HBase
The Data Variety

- Data from different sources have to be related to each other
- Different frequencies how tie data together to make meaning out of it?
- Applications have to be built on co-related data
- For vehicle management
  - Current location of the vehicle collected from GPS
  - Current velocity of the vehicle collected from OBD
  - Data collected at different frequencies.
  - Co-related to determine if speed limits are being violated
Data Reliability

• Will the sensor give back the same data point given
  • Under the same set of environmental conditions?
  • Impact of noise on the sensor

• How dependable are the data point collected?
  • Can it directly be used to provide application features?
    • E.g., Single data point temperature collected is 29.5°C
    • Comfortable temperature set at 30°C
    • Should the AC be turned on or off?
    • e.g., Latitude/Longitude collected is 12.967816 / 77.510983
    • Is it same as 12.967241, 77.511101?
    • Need a nearby function and not direct comparison?
Data Types and Data Integrity

• Impact of Customization

  • Different devices provide the same data
    • Data formats are different from different devices
    • Data from all these devices have to be mapped to a common schema
  • Different customers require different features
    • Data collected depends on features
    • Data co-relation and analytics depends on features
    • Have to be customizable what data can and need not be collected
Data Analytics

Should there be one Raw data DB for one customer? Or should it be shared?

Should there be a separate data collector + analytics setup for each customer? Can it be shared? (Based on volume)

Analytics for each customer separate
Community analytics across customers

Recognize different customers using data

Multi-tenant Application. Database is shared with isolation
Impact of customization on the Architecture
Scaling – Simple problem, tricky to solve

• Simple problem definition
  • As the number of devices/cars increase, the architecture should *scale up* to take the load

• Tricky to solve
  • Invest just enough for the current load, but architect to expand easily

• Standards ??

• Compliance Obligations?
And some non technical challenges

- Who is the owner of the valuable vehicle/consumer data?
- Who will the customer trust
- Who will use my data
- Who should be allowed to use my data
- Privacy

And many more.....
## The “digital” car: Here to Stay!!

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Fighter planes</td>
<td>20 M lines of code</td>
</tr>
<tr>
<td>High end cars</td>
<td>100 M lines of code</td>
</tr>
<tr>
<td>Electronics SW</td>
<td>&lt; 20% of car cost in 2005</td>
</tr>
<tr>
<td>Electronics SW</td>
<td>Almost 40% today</td>
</tr>
<tr>
<td>Innovation Spend</td>
<td>90% in Electronic Systems</td>
</tr>
<tr>
<td>Spend on innovation</td>
<td>US$ 105 B in 2014, 4% of revenue</td>
</tr>
<tr>
<td>SOC market</td>
<td>USD 31B, 7.5% growth</td>
</tr>
</tbody>
</table>

Huge, Mass of Unoptimized Lines of Code, Heterogeneous Architectures, Scalability, Reliability, Interoperability are challenges to managed simultaneously with increasing complexity of features and functionalities.