Realizing Autonomy

Stan Schneider, PhD
RTI CEO
IIC Vice Chair
Problem: Getting There is Dangerous and Slow

We have an obligation to automate driving.
RTI lives at the intersection of functional artificial intelligence and pervasive networking℠
The Industrial IoT

- RTI is the largest IIoT connectivity vendor
- 1300+ designs, many real-world programs across industries
- Full DDS, tools, services, support, secure & certified versions
200+ RTI Autonomous Vehicle Projects

• 50+ commercial systems
  – 10+ Passenger vehicles
  – 10+ EV startups
  – 5+ Software platforms
  – 8+ Trucks, mining vehicles, forklifts
  – 2 Flying taxi services
  – 2 Hyperloop & other
  – 2+ Autonomous ships
  – 2+ Underwater robots

• 100+ defense systems (land, sea, air)

• 75+ research programs (companies, universities, etc.)
Auto Industry Competition

- Style
- Driver Experience
- Efficiency
- Performance
- Safety

Best Software Wins
Design the System Around the Data

Application  
Data  
Application

Database

Databus

DDS is the standard that defines the data-centric databus

Data-centric storage and search of old data

Data-centric sharing and filtering of future data

Message Remote Objects
Client/server SOAs
Why Does Data Centricity Matter?

- Logically puts all data “inside” every application
- Apps read or write like local memory
- With full control over timing, reliability, filtering, security
Data Centricity Makes Mobility Transparent

Shared Global Data Space

- Application
  - Data
  - Application

- Device
  - Data

- Algorithm
  - Data

- Storage
  - Data

- Monitoring
  - Data

- Error Check
  - Data

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Data Centricity Allows *Data Defense*

- System edge
- Host
  - Machine/OS/Applications/Files
- Network transport
  - Layer 2-3 “pipe” security
  - Layer 4-5 “session” security

Important, “bolted on”, not enough

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- DDS: Dataflow Security
  - Control *application interaction*
  - Secures the data itself; no API!
  - Independent of transport, OS, chip

Perfect match to architecture: no code!
Data Centricity Simplifies Fault Tolerance
IIC Layered Databus Architectural Pattern

- End-User Applications
- Connect with RESTful/Web Sockets

- Traffic Management
  - Traffic Light Control
  - Congestion Management

- Road Management
  - Environmental & Road Conditions

- Probe Data Collection (Sensors)
- Environmental Weather
- Dynamic Vehicle Location

- Collision Avoidance
- Navigation
- Safety Certified

Public Internet

Fleet Management

V2V & V2X

In-Car Platform

Cloud Databus

Site Databus

Unit Databus

Machine Databus

Think

HMI

Sense

Act

Unified Data Model
AV Control

- Sensor Fusion
- Localization
- Vehicle actuation
Large Data Streaming

Autonomous Driving

LIDAR UNIT
- Constantly spinning, it uses laser beams to generate a 360-degree image of the car’s surroundings

RADAR SENSORS
- Measure the distance from the car to obstacles

CAMERAS
- Uses parallax from multiple images to find the distance to various objects. Cameras also detect traffic lights and signs, and help recognize moving objects

ADDITIONAL LIDAR UNIT

MAIN COMPUTER

By Guilbert Gates | Source: Google
# How to Deal with the Data?

<table>
<thead>
<tr>
<th>Source</th>
<th>Type</th>
<th>Size</th>
<th>Frequency</th>
<th>Volume (approx.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 Cameras</td>
<td>2D high-res. video stream</td>
<td>8x 1-4 Mpixel/frame x 30 frames/s x 12-24bit/pixel</td>
<td>30 Hz</td>
<td>2.5-20 Gbit/s</td>
</tr>
<tr>
<td>4 Lidar sensors</td>
<td>3D point cloud</td>
<td>4x 300k-3M 3D points /s * 24bit/point</td>
<td>5 Hz</td>
<td>30-300 Mbit/s</td>
</tr>
<tr>
<td>5 Radar sensors</td>
<td>Object/target list</td>
<td>bytes to kbytes</td>
<td>60 Hz</td>
<td>~10 kB/s</td>
</tr>
<tr>
<td>16 Ultrasonic</td>
<td>Object/target list</td>
<td>bytes to kbytes</td>
<td>10 Hz</td>
<td>~10 kB/s</td>
</tr>
<tr>
<td>1 GPS</td>
<td>Data message</td>
<td>A couple of bytes</td>
<td>20-200 Hz</td>
<td>~10 kB/s</td>
</tr>
<tr>
<td>Control commands</td>
<td>Message</td>
<td>A couple of bytes</td>
<td>50-250 Hz</td>
<td>~10 kB/s</td>
</tr>
<tr>
<td>Status/error handling</td>
<td>Data/string message</td>
<td>Whatever needed</td>
<td>Whenever needed</td>
<td>Whatever needed</td>
</tr>
</tbody>
</table>

12 Gb/s or 1.5 GB/s or 90 GB/min or 5 TB/h or 100 TB/d

Approximately and assuming 20h of operation per day

5G data rate: 100Mbps (cell edge) to 10Gbps (theoretical)
Solution: QoS Controls Dataflow

<table>
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<tr>
<th>Data Source</th>
<th>Data Type</th>
<th>Data Volume</th>
<th>Data Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cameras</td>
<td>Video Stream</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lidar</td>
<td>Data List</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Radar</td>
<td>Point cloud</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GPS</td>
<td>Bin data struct</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control Cmd</td>
<td>Bin data struct</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Error</td>
<td>Text String</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Carbots need many different dataflows:
  - Volume
  - Frequency
  - Latency
  - Reliability
  - Security
- A single databus that can handle all greatly simplifies the system
Problem: Central Data Access with Powerful Compute

• Good:
  – Low Latency
  – High throughput
  – Access to all data

• Bad
  – Expensive wiring
  – Hard to add compute
  – Hard to address level 4 & 5
Data Centricity enables new architectures that are fast, distributed, and reliable.
Autonomy Needs Subsystems

- Situation Awareness
- Planning
- Vehicle Control
- Logging
- Error Management

Sensing
- Cameras, LIDAR, Radar
- Data Fusion
- Localization

Vehicle Platform

Data Fusion

Databus

Cloud Services
- Traffic
- Maps

Visualization

Navigation

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Solution: Data Centricity Decouples Subsystems

- **Flow**
  - Automatically discovers all data
  - Manages bandwidth
  - Efficiently filters at the source
  - Makes *all data available everywhere*

- **Space (Location)**
  - Move functions from ECUs, Fog, Cloud
  - Use any transport
  - Connect despite IP changes

- **Time**
  - No servers; no startup sequence
  - Add/remove functions any time
Evolving Architectures

Central CPU/GPU

Chassis
ECU

Body
ECU

Powertrain
ECU

Infotainment
ECU
Problem: “Truly Autonomous” Isn’t
Solution: Connect Control Room to Vehicle

DDS excels at control rooms for real-time operations

DDS delivers the data autonomous vehicles need to operate
The Age of Smart Machines
Are Carbots Safe?
Are Drivers Safe?

Autonomous vehicle at-fault accident rate is much less than humans

HUMAN ERROR ACCOUNTS FOR 94% OF ROAD ACCIDENTS
A Better Smart Machine World

The real value is a common architecture that connects sensor to cloud, interoperates between vendors, and spans industries.

You don’t compete against competitors.
You compete against market transitions.

– John Chambers

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The Network is the Car
Connect!!

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