Automotive IP Cores: Challenges & Solutions

D&R IP-SoC Days Shanghai

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Cameras
20-40 MB/sec

GPS
~50 KB/sec

Sensors
1 - 3 MB/sec

LIDAR
10-50 MB/sec

GBytes/sec, TBytes/hour to be communicated, processed, and stored
Some Challenges IP Cores Need to Address

- The vehicle network has to provide **higher bandwidth** BUT preserve the low-latency, deterministic time communication AND keep the wiring cost as low as possible.

- **Compression** is key decrease power & cost for data communication and storage.

- ADAS systems rely on **video** that not only needs higher bandwidth but also needs to be delivered with minimum latency and be of high quality under any lighting conditions.

- Smart & connected sensors need to do some level of processing at the edge and rely low-power, **secure embedded processors**.
Communications in Vehicle Networks Today & Tomorrow

<table>
<thead>
<tr>
<th>Domain</th>
<th>Latency</th>
<th>Bandwidth</th>
<th>Network</th>
</tr>
</thead>
<tbody>
<tr>
<td>Powertrain</td>
<td>&lt; 10 us</td>
<td>Low</td>
<td>CAN</td>
</tr>
<tr>
<td>Chassis / Safety</td>
<td>&lt; 10 us</td>
<td>Low</td>
<td>Flexray, CAN-TT</td>
</tr>
<tr>
<td>Body &amp; Comfort</td>
<td>&lt; 10 ms</td>
<td>Low</td>
<td>LIN, SENT, CAN</td>
</tr>
<tr>
<td>Driver Assistance &amp; Safety</td>
<td>&lt; 250 us to &lt;1 ms</td>
<td>10-100Mbps per camera</td>
<td>Ethernet</td>
</tr>
<tr>
<td>Human-Machine I/F</td>
<td>&lt;10 ms to &lt;100</td>
<td>Few Kbps to few Mbps</td>
<td>Ethernet, CAN</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>LIN, SENT</th>
<th>CAN 2.0</th>
<th>CAN-FD</th>
<th>TTCAN</th>
<th>Flexray</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost</td>
<td>Very Low</td>
<td>Low</td>
<td>Medium</td>
<td>Medium</td>
</tr>
<tr>
<td>Max. Bit Rate</td>
<td>20 Kbps</td>
<td>1 Mbps</td>
<td>10 Mbps</td>
<td>10 Mbps</td>
</tr>
<tr>
<td>Messaging</td>
<td>Deterministic</td>
<td>Event-Triggered</td>
<td>Event &amp; Time Triggered</td>
<td>Event &amp; Time Triggered</td>
</tr>
</tbody>
</table>

**TSN Ethernet** is the new technology that enables low-cost, high-bandwidth, low-latency communications with traffic shaping capabilities able to accommodate all automotive requirements.
CAST CAN2.0/CAN-FD IP Core

- Survived three CIA Plug Fests
- In production use
- Most Highly Featured CAN core in the market
- Reference design & sample drivers for easy evaluation and integration
CAST TSN Ethernet Subsystem

- Eases the implementation of TSN ethernet endpoints.
- Integrates hardware stacks:
  - Time Synchronization (IEEE 802.1AS)
  - Traffic Shaping/FQTSS (IEEE 802.1Qav and IEEE 802.1Qbv)
  - Ethernet MAC (Optionally)
- Requires minimum software support, enables ultra-low-latency communication
- Proven in IIC and LNI Plug Fests
- Can be integrated with UDP/IP hardware stacks, and/or low-latency compression cores
UDPIP Hardware Stack

- Hardware Stack Implementing in custom hardware UDP/IP, ARP, ICMP, IGMP, DHCP and supporting TSN Ethernet
- With NetCMD module enables remote access to any AXI/AHB address

- Minimize latency for streaming over Ethernet
- Operate without any software assistance
- Enables monitor and control over Ethernet
CAST GZIP Compression Cores

- Industry-standard for compressing sensor and other data, either on the application or on the file-system level

- Configurable to adopt to different needs:
  - Throughput-optimized versions provide over 100GBps
  - Size-optimized versions for 100K gates.
  - Latency-optimized version, have <100 cycles latency

- Allows better utilization of available network bandwidth

- Optimizes cost of local storage
Automotive Video Challenges

Need real-time response from tens of cameras
Real-time Response —
Live video streaming requires system low-latency

Latency
50 ms
1.5 frames
1080 lines

Input Video
Encoder
FIFO
Channel
DSB
Decoder
Output Video

Absorbs temporal over-production of video stream
Supplies temporal over-demand of video stream
CAST Video Over IP Subsystems

- H.264 and MJPEG video-over-IP sub-systems with deep sub-frame, end-to-end latency
CAST WDR/HDR

- Essential for machine vision in vehicles
- Improves image quality to create clear and sharp images under any lighting conditions.
- Processes the merging of 2, 3 or 4 exposures and provides tone mapping, white-balance adjustment, back correction and 2D noise reduction filter
CAST Processors

CAST 8051 and BA22 32-bit processors currently used in many automotive sensor products:

- **8051**: Small, low-power
- **BA20/21/22**: 32-bit embedded processors
- **Geon Secure Execution Processor**: BA22 enhanced with advanced security features
  - Protects sensitive code and data during execution, storage, and transfer to/ from the processor
  - Uses two or more cryptographically isolated secure execution contexts
**CONTROLLED & PROCESSORS**

- 32-bit BA2x Family
  - Application Processors
    - Full & Basic
  - Embedded Processors
    - Cache-Enabled
    - Deeply Embedded
    - PipelineZero Low-Power
  - Dev & Debug Packages
- 8051 Compatibles:
  - Super-Fast Advanced
  - Fast & Mature; Tiny
  - Legacy-Configurable
- 16-bit 80251s: Fast, Tiny

**COMPRESSION**

- Lossless Data Compression
  - GZIP/ZLIB/Deflate
- H.264/AVC Encoders:
  - Low-Power through Ultra-Fast; Intra-Only
- H.264/AVC Decoders:
  - Low-Latency, Low-Power
- JPEG & Motion JPEG:
  - Encoders & Decoders: Baseline, Extended 16-bit, Ultra-Fast
- JPEGLS:
  - Lossless image compression
- Video Over IP Subsystems & Ref. Designs
- H.265/HEVC Decoder
- WDR/HDR Image Processor

**SECURITY & ENCRYPTION**

- AES, Programmable, GCM, CCM
- Key Expander
- Hash Functions
  - Keccak/SHA-3
- SHA-1, SHA-256, MD5

**INTERCONNECTS**

- UARTS, I2C/SMBUS, SPI & QSPI
- SDLC & HDLC, Ethernet MAC
- PCI Express X1/X4 & X8 controllers, app interface
- TSN Ethernet
  - 802.1AS Hardware Stack
  - TSN End-Point Sybsystem
- CAN2.0 & CAN FD
- LIN & SENT/SAE J2716

**PERIPHERALS**

- AMBA Infrastructure Cores
- Device Controllers:
  - Smart Card Reader, TFT-LCD
  - Display Parallel NOR Flash & Serial NOR Flash (QSPI-XIP)
- Network Stacks:
  - MPEG Transport Stream
  - UDP/IP Stack
  - Hardware RTP Stack
- Legacy Peripherals:
  - DMA Controllers, UARTs, Timer/Counter
Thank You.

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