Linux Embedded applications in Machine Vision

Embedded Linux Conference – Europe (Grenoble)
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Pascal PELLET
e2v presentation

Machine Vision

GigE Vision protocol

e2v GigE Vision IP

Conclusion & Evolution
e2v presentation: Product Offer

Medical, Industrial & Emerging Imaging
- CCD sensors
- CMOS sensors
- Medical Cameras
- Mixed Signal ASICs
  - Sensor
  - Signal conditioning
  - ICs

Space & Scientific Imaging
- Space
- Scientific Imaging
- Converters & Microprocessors
  - Broadband Data Converters
  - Assembly & Test services
### Fields of Application

- **Aerospace**
- **Defence**
- **Automotive**
- **Industrial Imaging**

- **Telecom**
- **Instrumentation**
- **Medical**
- **Industrial**
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Machine Vision

GigE Vision protocol

e2v Gige Vision IP

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For industrial market, e2v semiconductors is a world leader in development and manufacturing of camera for Machine Vision.
Machine Vision application

→ System based on cameras and acquisition systems (frame grabber, PC, ...)

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Machine Vision application

Used in industry for
- Foods (sort rice, fruit inspection, …)
- Checking goods (web, papers, wood, glass, flat panel)
e2v, with other Machine Vision companies, contributes to the development of industrial standards, including:

- Camera Link
- GigE Vision
- GenICam standard for software access
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Machine Vision

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e2v GigE Vision IP

Conclusion & Evolution
GigE Vision protocol: Overview

- GigE Vision® is a camera interface standard developed, based on Ethernet protocol.
- Main benefits
  - Fast image transfer: High bandwidth (1000 Mbps) allows large uncompressed images to be transferred quickly in real time
  - Low cost standard cables over very long lengths (100 meters)
  - Data transfer up to Standard gigabit Ethernet hardware allows single/multiple camera connection to single/multiple computers
- This protocol is managed by AIA (Automated Imaging Association)
  - www.machinevisiononline.org
- e2v is a member of the Gige Vision development committee with other companies:
  - NI, Matrox, Pleora …
GigE Vision protocol: Overview

- **GEV Protocol**
  - GVCP: GigE Vision Control Protocol
  - GVSP: GigE Vision Stream Protocol
  - GEV is based on different phases
    - IP address allocation
    - Discovery
    - Connection
  - These protocols use UDP IPv4 as the transport Layer Protocol

- **Device description**
  - An xml file describes all the device capabilities (compliant with the GenICam specification)
    - One register corresponds to one feature
    - Understandable by any GenICam PC software to monitor the camera
GigE Vision protocol: GigE Vision Control Protocol (GVCP)

- GVCP is an application layer protocol relying on the UDP transport layer protocol
- GVCP provides a set of commands and acknowledges messages to be exchanged between GEV device(s) (camera) and a GEV application(s) (host)
  - Read/write Register
  - Read/Write Memory
  - Discovery
- Asynchronous Message can be sent by the device: event

- GVCP packet:

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<th>Size</th>
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<tr>
<td>GVCP header</td>
<td>8</td>
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<tr>
<td>Max GVCP Payload</td>
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</tr>
<tr>
<td>Total</td>
<td>576</td>
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</table>
**GigE Vision protocol:**
**GigE Vision Stream Protocol (GVSP)**

- GVSP is an application layer protocol relying on the UDP transport layer protocol.
- It allows an application to receive data blocks from a device.
- A data block is divided into 3 elements:
  - Data leader: advises the host of the beginning of the data block
  - Data Payload: data
  - Data Trailer: advises the user the end of the data block

- Payload types:
  - Image
  - Raw data
  - File
  - Chunk data
  - Device Specific

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Machine Vision

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Conclusion & Evolution
In order to develop a camera supporting GigE Vision, e2v has developed a generic platform based on:

- ARM processor (Atmel AT91SAM9263)
- Linux v2.6.24
e2v GigE Vision IP: Base bricks to products

New base bricks: Camera link IP  New products:

- Camera Link LineScan Camera:
  - AviivA EM2CL – AviivA EM4CL
    - 160 Mpixels/sec
    - Mono8-12bit

- GigE Vision LineScan Camera:
  - AviivA EM1GE
    - 120 MPixels/sec
    - Mono8/12bit

- Characterization boards (internal use):
  - CCD and CMOS Imaging sensors
  - ADC …
e2v GigE Vision IP:
fixe issues

- e2v fixed issues for its products:
  - Upgradable
  - Reliability
  - Reduce the development time
e2v GigE Vision IP: Benefits

→ What does this platform bring for e2v products

→ Project
  → Re-use
  → Cost Saving
  → Reliability / Improvement
→ Development flow
  → Support and knowledge
  → Validation and testability
  → C++ (abstraction, coding efficiency)
→ Linux services
  → TCP/IP Stack
  → PPP
  → File system management
  → ARP
  → Multi thread
e2v develops a GigE Vision IP based on this generic platform and a FPGA
e2v GigE Vision IP: FPGA IP

- Interfaces with the PHY
- Manages Ethernet packet
  - Filter with MAC Address, broadcast packets
  - Offers RX, TX FIFOs, registers area to the processor
- FPGA Interruption: advises the processor that Ethernet packets are available
- RX FIFO: Ethernet packets sent by the host
- TX FIFO: Ethernet packets sent to the host
- Manages GVSP packet (streaming)
e2v GigE Vision IP: Ethernet driver

- Configures the PHY
- Interfaces with the FPGA
- Configures the FPGA (Mac Address …)
- Copies packets from FPGA RX FIFO to the TCP/IP stack
- Copies packets from TCP/IP stack to the TX FIFO
e2v GigE Vision IP: GEV driver

→ Access to FPGA GEV Registers
e2v GigE Vision IP: EthernetTL library

- Loads the FPGA
- Mounts the Ethernet driver
- Sets Mac address
e2v GigE Vision IP: GigE Vision Library (libGEV)

- Offers all GigE Vision based features
- Mounts the Ethernet connection (through ethernetTL)
- IP address Allocation
- Discovery
- Read/Write memory/register
- GEV registers configuration
For the control, the gigabit per second is not required.
  - Max speed: 30Mbit/sec
  - To improve speed:
    - Use DMA to read/write into FPGA FIFOs

For the streaming the gigabit is required
  - Max transmission speed 984Mbit/sec
Conclusion & Evolution
Performance

→ Software Interoperability
  → With the main GEV application software
    → National Instrument
    → Matrox
    → GigE Vision compliant

→ Reliability
  → Memory allocation
  → Temperature
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Other GigE Vision applications:
- Medical: X-ray application
- Evaluation kit/characterization board for image sensors
- Spectrometry: Swifts (Minalogic project)
- Smart camera (no real time processing)
  - Gain control
  - Light control
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Next: 10 gigabit Ethernet
- Optical fiber
- Copper wire

Power Over Ethernet
- video surveillance
Any Question ???