GigE Vision Seminar

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Agenda

1. The GigE Vision Standard
   a. GigE Vision Summary
   b. Ethernet Technology
   c. GigE Vision Components
   d. Relation to GenICam
2. Upcoming GigE Vision 1.1 and beyond
3. Expandability
4. North American Market
5. Study Cases

GigE Vision Objectives

- Minimize the effort for integrating a camera in new applications
- Establish and grow a market for Ethernet cameras
- Leverage existing Ethernet technology and infrastructure
- Make cameras interchangeable
- Support all camera types, including areascan, linescan, mono and color, IR, etc.
- Reduce support costs and software costs
- Grow the Machine Vision market

GigE Vision Backgrounder

- First proprietary Gigabit Ethernet cameras around 2004
- Specification released in May 2006
- Acceptance rate by the market so far is great considering it is a totally new specification. Many OEM's are moving to it.
  - Can easily replace analog cameras in many systems. Analog market quickly diminishing in Europe/North America.
  - Firewire is a tougher competitor due to similarities in deployment (digital, no frame grabber, similar bandwidth).

GigE Vision Committee

- Created in June 2003
- Sponsored by AIA
- 10 companies from Machine Vision industry created the first version
- Committee is open to any AIA member
- Typically 2 general meetings per year, supplemented by technical meetings
  - Next technical meeting in Montreal, Canada (October 2008). Combined with GenICam meeting to favor complementary of both specifications.
  - Next general meeting in Stuttgart, Germany (November 2008)
- Technical meetings focuses on advancing the standard (new features).

Building Blocks of GigE Vision

GigE Device Discovery mechanism

- Defines how compliant cameras obtain IP addresses and are identified on the network

GigE Vision Control Protocol (GVCP)

- Defines how to control GigE Vision-compliant cameras and specify stream channels

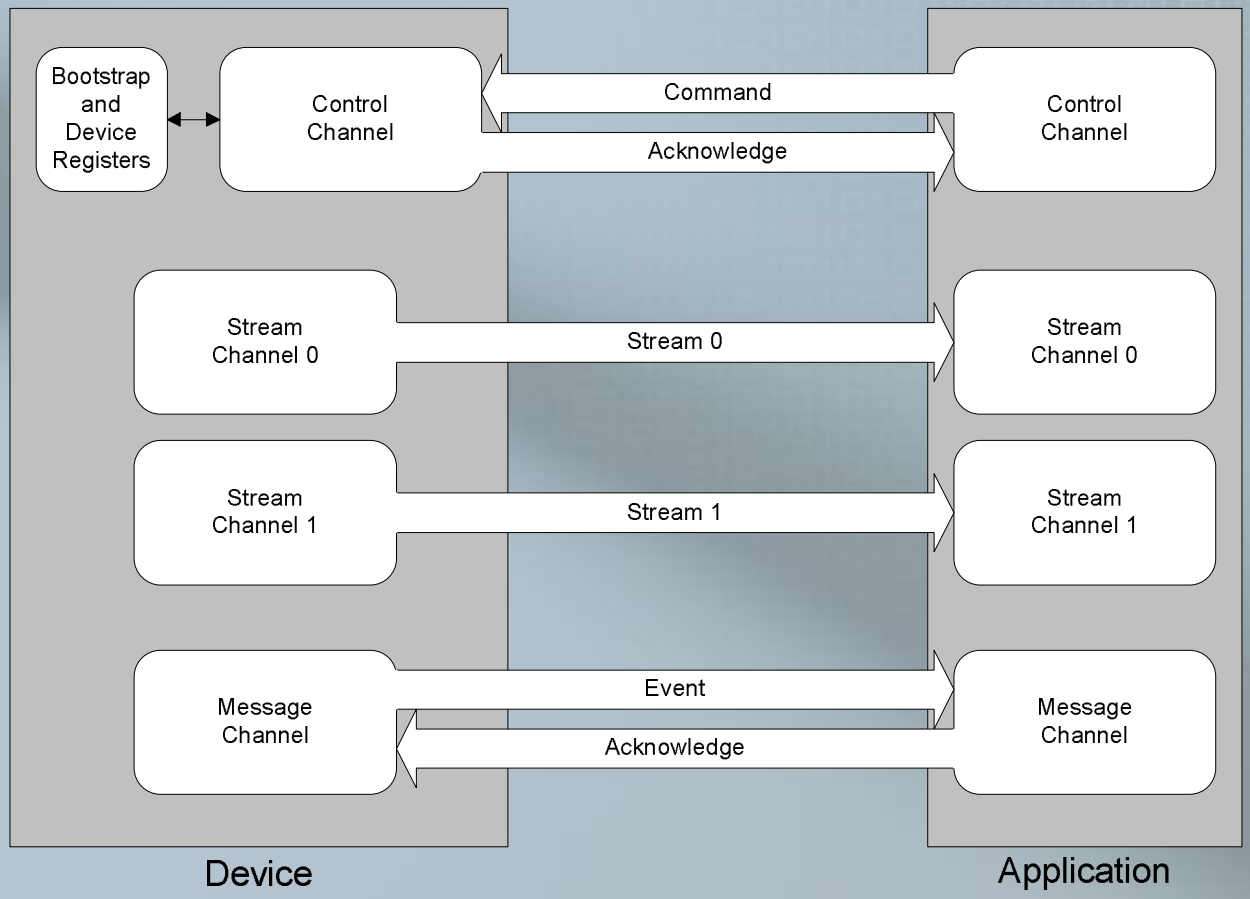
GigE Vision Stream Protocol (GVSP)

- Defines data types and describes how images are transmitted

Bootstrap Registers

- A set of standardized camera registers to control the camera

Communication Channels of GigE Vision



Transport Protocol

TCP: Connection-oriented protocol

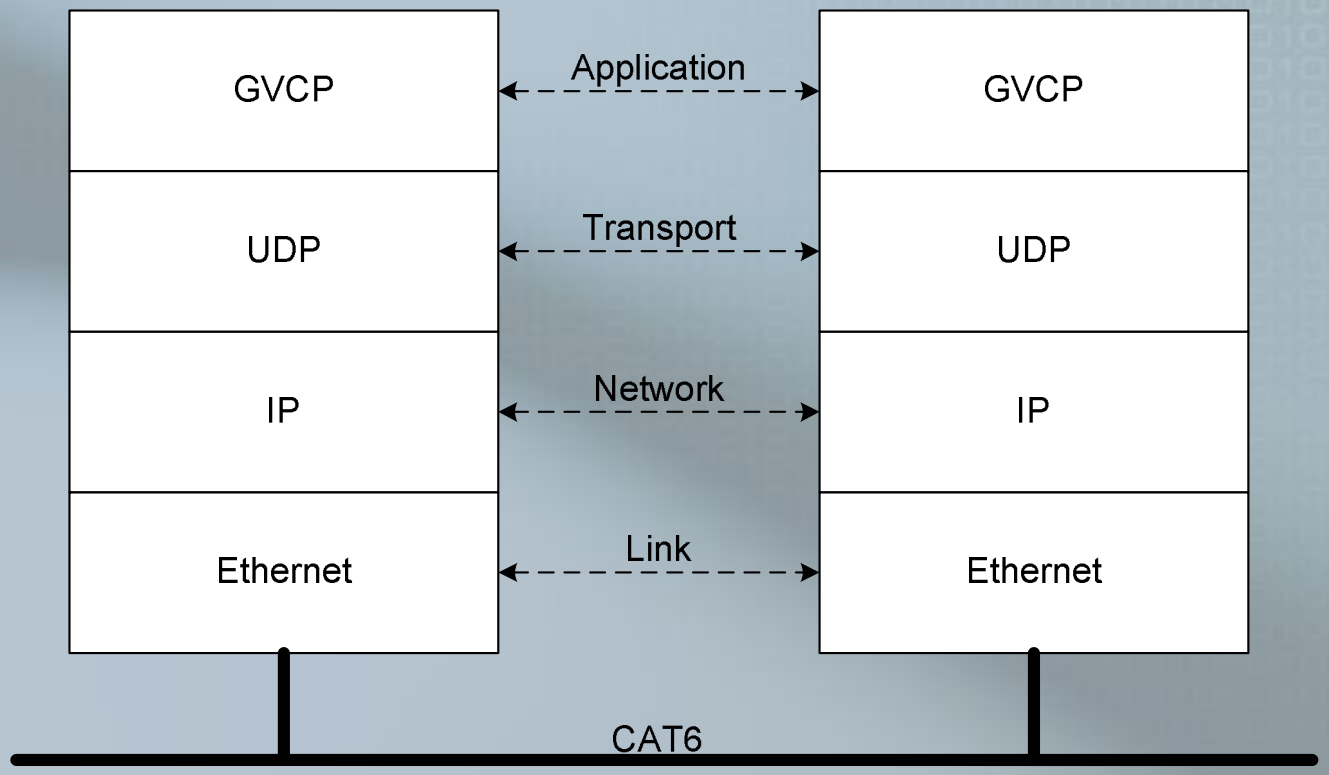
- Flow control
- Reliability and Error Recovery
- End-to-end communication

UDP: Connectionless protocol (no handshake)

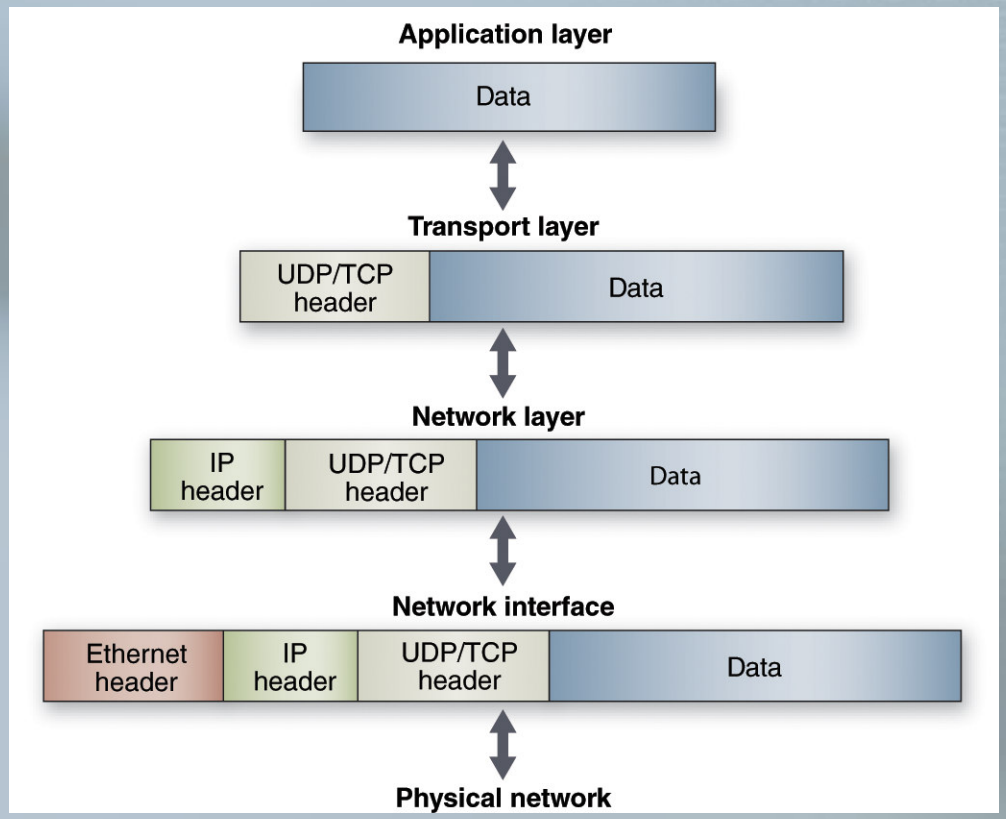
- Minimize communication overhead
- Requires application layer to build robustness.

*GigE Vision uses **UDP** to limit overhead*

Communication Stack



UDP Packet Content



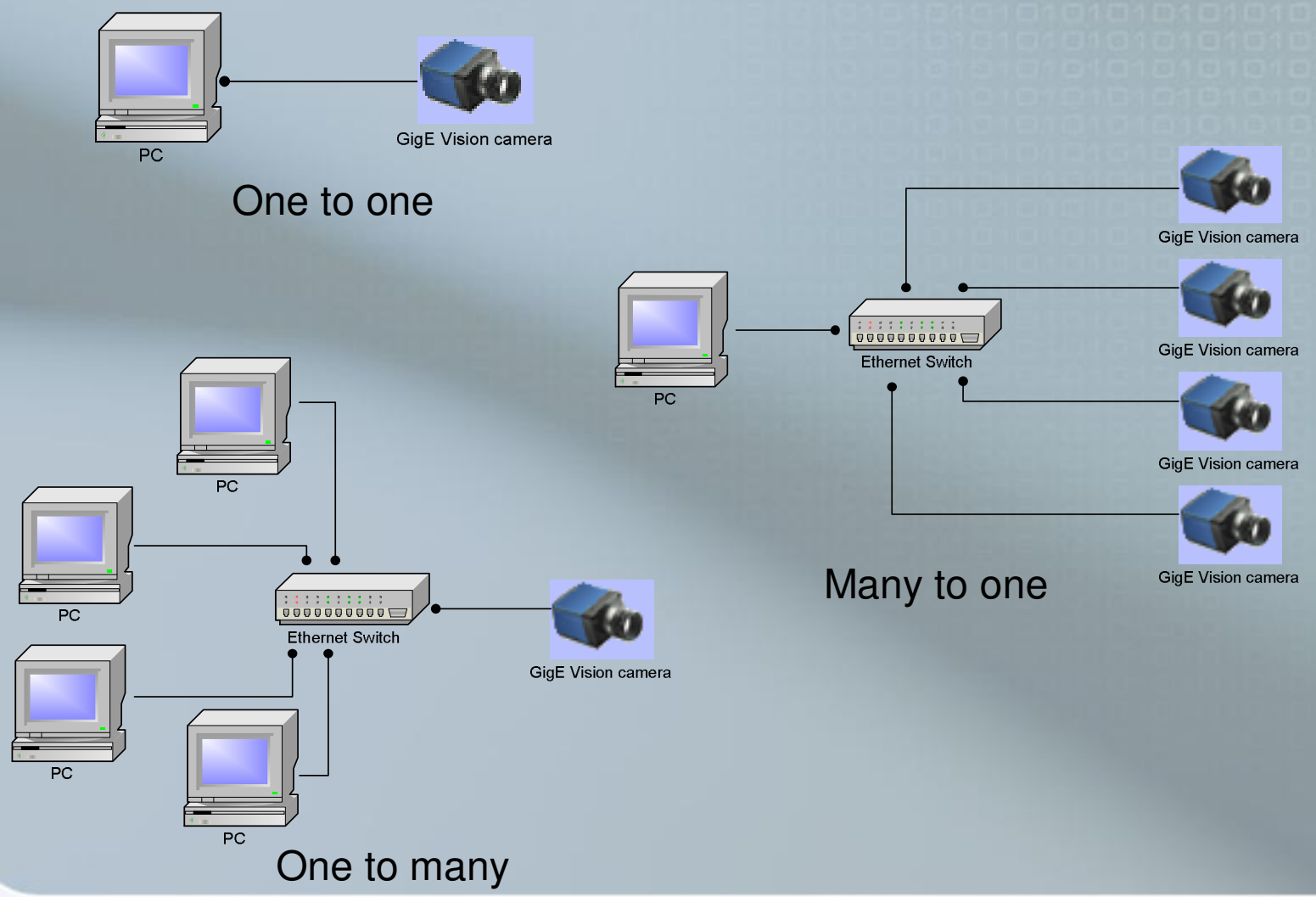
Selecting Destinations

Unicast: IP packet is sent to a single destination. Only mode supported by TCP.

Broadcast: IP packet is sent to all devices on the subnet. Inefficient use of the subnet bandwidth since all devices' UDP stack must filter out this request if they do not use it.

Multicast: IP packet is sent only to registered devices. More efficient than broadcast, but requires special routers.

Vision System Topology



Camera Discovery

Purpose

- Automatic identification of GigE Vision cameras on the subnet

Benefits

- Automatic identification of cameras and its capabilities
- Greater flexibility and system control
- Remote service and reconfiguration

How Camera Discovery works

- A broadcast message is issued to find all cameras.
- Cameras respond with their IP address, model, serial number…
- Application can then take control of cameras using GVCP

Camera Discovery

For Camera Discovery to work, cameras need an IP address.

GigE Vision supports 3 methods:

- DHCP (managed networks)
- LLA (unmanaged networks)
- Persistent IP (fixed and manual configuration)

GVCP – Control Protocol

A set of commands used to:

- Establish control of the camera
- Read and write camera registers
- Configure the stream channels
- Control camera behavior (frame rate, exposure, I/O response, and event notification)

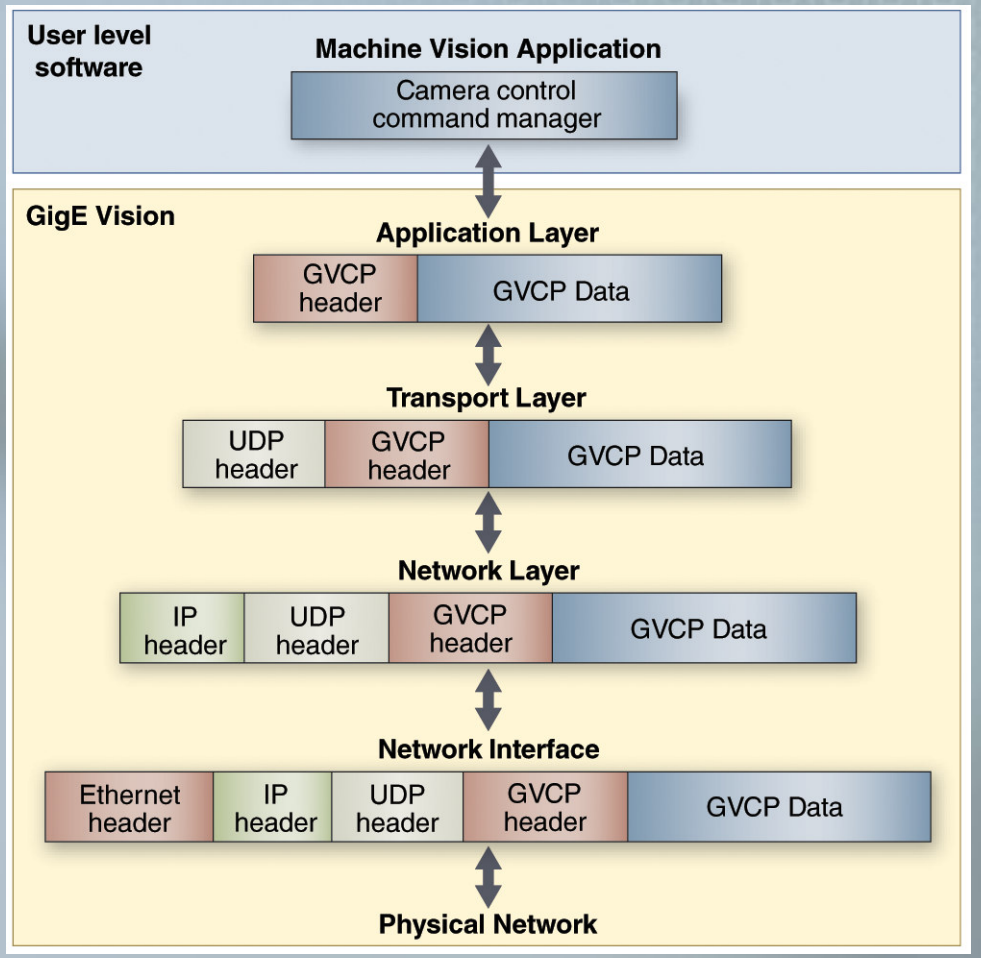
- Registers used to configure acquisition (ex: exposure mode) are camera-specific and defined using GenICam XML file.

- Registers used to configure the Ethernet connection (control, stream and message channels) are defined by GigE Vision.

GVCP – Protocol Stack

Once cameras are identified:

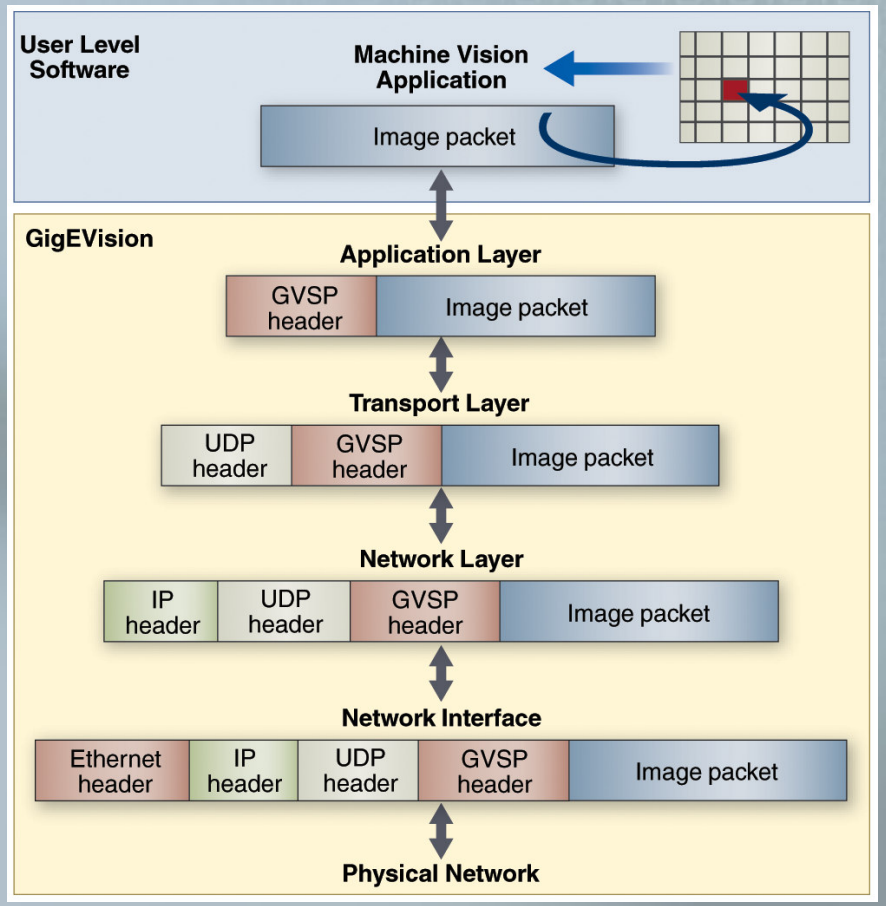
- User applications can open a control channel to the camera and configure it.
- Only one application can control the camera at a time.
- Once configured then image acquisition can begin (GVSP).



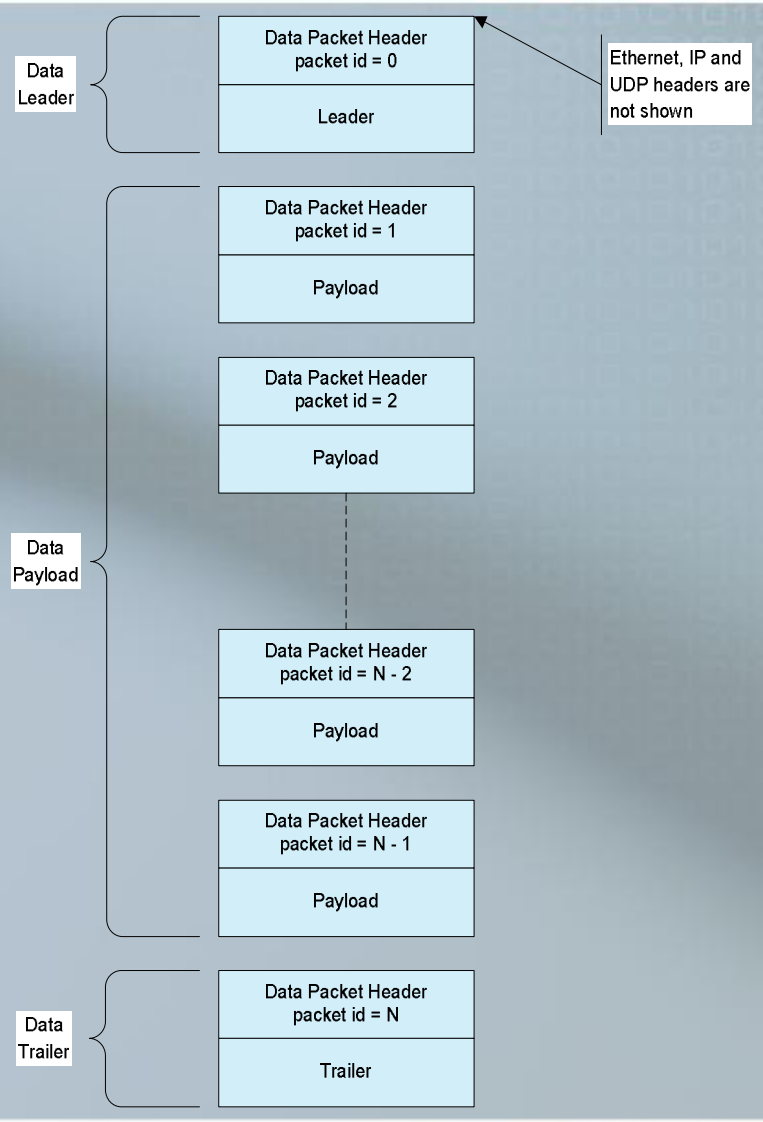
GVSP – Stream Protocol

Once configured, image transmission can begin

- GVSP defines how images are packetized (data formats, resolutions)
- Each packet is identified with a BlockID (GVSP header), associating the packet with a specific image.
- Robustness ensured using a Packet Resend mechanism



GVSP Image Packets



Message Channel

- Used to notify the application of asynchronous events on the camera.
- Based on GVCP protocol, but flow is in the other direction.
  - For instance, Message Channel can be used to notify the application that the logic level of an input pin has changed on the camera.
- A common 64-bit timestamp is used by the stream and message channel to tag events.

Feature Naming Convention

- GigE Vision has 7 mandatory features to control basic free-running image acquisition.
- GenICam (XML file) provides additional recommendations to name the typical features found in cameras (such as gain, trigger mode, etc.).

➢ This is fundamental for **interoperability**.

Validation Framework

- GigE Vision committee provides an automated software tool to validate cameras against requirements from the specification.
- This tool essentially checks for device interoperability.

- Running the tool is an integral part of camera registration. Additionally, the Compliancy Matrix must be submitted for registration.

➢ Cameras and Applications must be registered with AIA to use the GigE Vision logo.

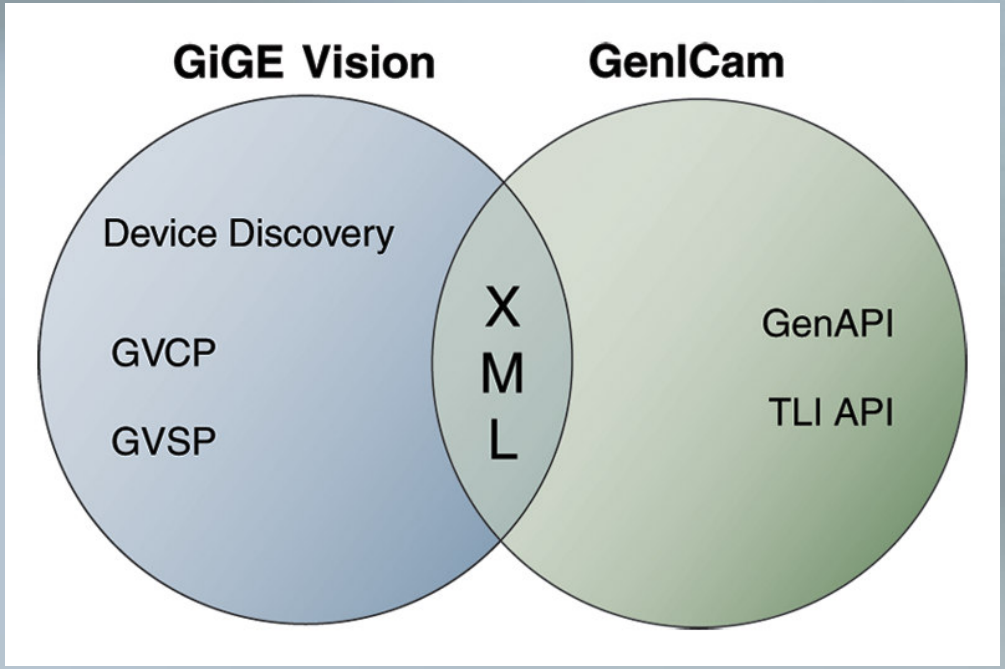
GenICam

- 3 components:
  - **GenApi** (XML file)
  - **Standard Feature Naming Convention**
  - **GenTL** (Transport Layer Interface)
- The camera stores locally a description of its acquisition registers and features into an XML file. This allow for different register mapping.
- These acquisition registers represent the features supported by the camera.

➢ Providing a suitable XML file is all it takes for a camera to be GenICam compliant!

Relation To GenICam

- XML (eXtensible Markup Language) is a language to store information.
- GenICam defines the syntax of this file for cameras
- Cameras report registers and features via this file



Upcoming GigE Vision Versions

- Version 1.1 planned for release at Stuttgart Vision 2008. It contains :
  - Firewall-friendly
  - Simultaneous software trigger of multiple cameras using broadcast
  - Possibility to provide many documents (such as datasheet and user manual) from the camera flash memory.
  - And many others!

Upcoming GigE Vision Versions

- Proposal for non-streaming devices
  - Configuration of non-camera peripherals using GigE Vision protocol (ex: light source, I/O box).
  - Key is to recuperate the XML Device Description file concept.
  - Different type of devices can be controlled using the same software.
  - Simplifies cabling since all devices would be based on Ethernet. Can share Ethernet switches.

Upcoming GigE Vision Versions

- Version 2.0: possible additions to discuss…
  - Latest flavor of the Internet Protocol (IPv6) will ease IP address management (IP address size increases from 32 to 128 bits)
  - Option to use a more robust protocol (TCP) to benefit from hardware offload engines. Could be useful for wireless.
  - Formalize synchronized timestamps from multiple cameras (using IEEE1588)
  - Work on 2.0 not started yet, these are just ideas raised during the technical meetings to discuss once we are done with release of 1.1
- *The **future***: IEEE just started working on 100Gigabit Ethernet
  - IEEE 802.3ba working group formed in December 2007

Expandability

- GigE Vision inherently benefits from advances made to Ethernet by IEEE:
  - Fiber optic link (ex: 10GBASE-SR)
  - 10Gigabit Ethernet (10GBASE-T, ratified in September 2006 for twisted-pairs)
  - Power-over-Ethernet (IEEE 802.3af)
- No need to modify the specification to build a GigE Vision camera with the above features, all this is possible **now**!
  - ➢ This is because GigE Vision is built on the Ethernet protocol.

10Gigabit Ethernet

- Fiber optic and coax versions have been available for a while
- IEEE 802.3an (copper, over twisted pair)
  - Very new. NICs and Ethernet switches are not readily, and expensive
    - SMC Networks offers the SMC8724-10BT (24 ports) for $25k. So it is roughly **$1000 per port**!!!
  - No killer applications to speed-up desktop deployment. Mostly a server communication link.
  - Expecting price to drop slowly since this is not targeting consumer applications. This will delay adoption rate for Machine Vision.

10Gigabit Ethernet

- Standard to get more traction in 2009 when NIC becomes readily available (for twisted-pair)
- Initial product cost may slow adoption rate versus Camera Link established leadership

- Little PHY availability at this time
- Power dissipation a big concern for cameras

- Expecting 10GE cameras to slowly see the *light* in 2011

Other IEEE Standards

- Power-over-Ethernet (IEEE 802.3af)
  - Offers about 10W (at 48V) usable by camera
  - Upcoming version to triple the power limit
  - Needs specialized Ethernet switches to inject power
- Wireless Ethernet (IEEE 802.11)
  - Needs robust protocol due to large number of packet loss (lots of retransmission).
  - Current Wi-Fi bandwidth is very low for vision applications (~19 Mbit/s effective throughput)
  - Need encryption and power cables
  - But this technology is rapidly evolving!

GigE Vision Benefits

- **Cost**: Camera slightly more expensive than Firewire, but system cost goes down (no frame grabber).
- **Cable Reach**: 100 meters, increased distance with use of switches or fiber optic
- **Robustness**: Ethernet CRC and PacketResend
- **Plug and Play**: Support for unmanaged network.
- **Infrastructure**: Compatible to existing Ethernet network (commodity products)
- **Migration Path**: 10G, IPv6 and wireless, Power-over-Ethernet
- **Multicasting**: Multiple destinations

- Can share same infrastructure as EtherNet/IP and Modbus/TCP for industrial systems

GigE Vision Drawbacks

- **Depacketization**: Overhead to reconstruct the image from packets, requires CPU to copy data.
- **Quality of Service** (QoS): No guaranty of bandwidth; work around by using point-to-point connection (camera directly to NIC).
- IP **network configuration** and IP conflicts: MV market is not familiar with IP configuration, need good documentation.
- Level of **maturity** of software packages, though this is rapidly changing.

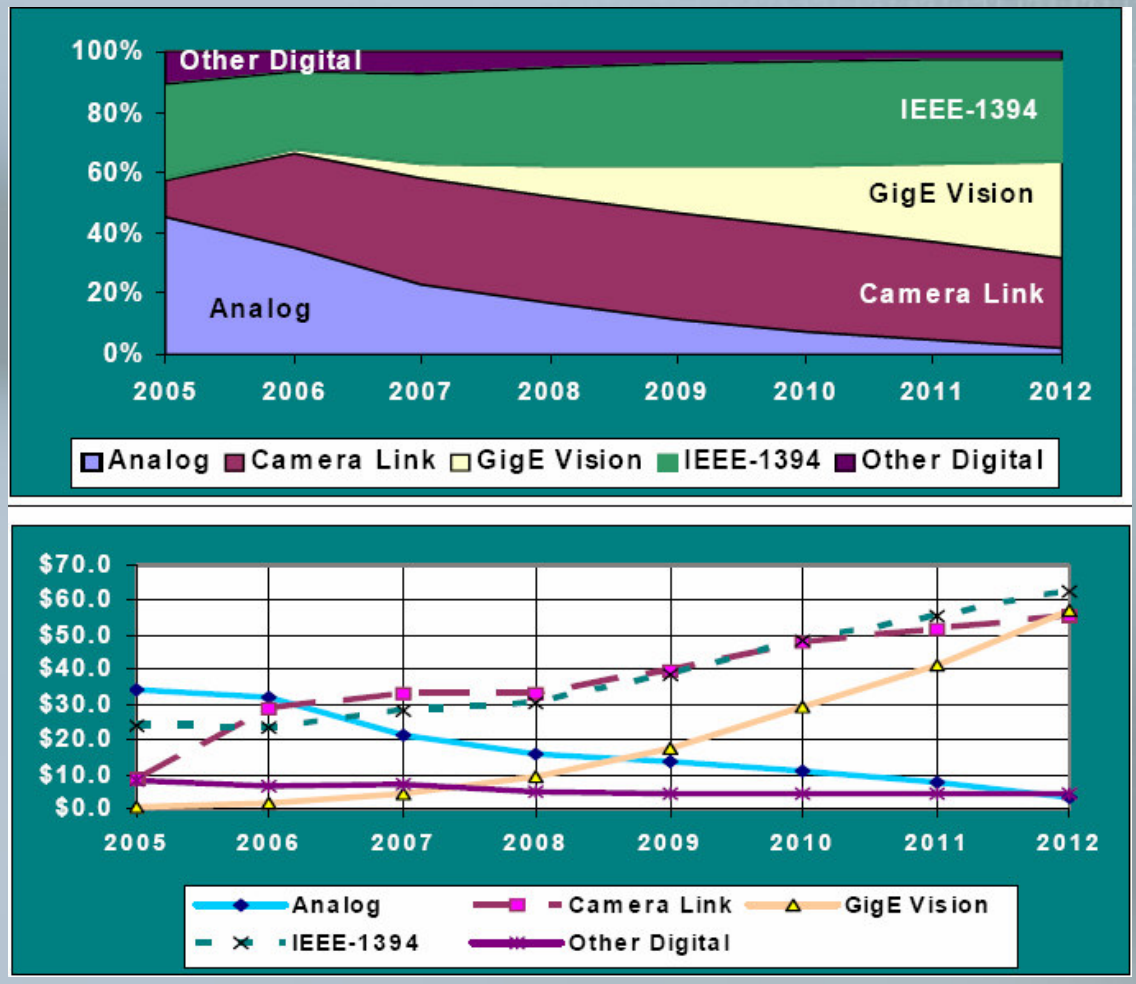
GigE Vision Market

- Both North America and Europe have rapidly adopted GigE Vision.
- Migration out of analog cameras is a prime market for GigE Vision.
- Due to its digital nature and long cable length, GigE Vision is used in some applications outside of the Machine Vision industry.
- GigE Vision will have an impact on the entry level Camera Link cameras (BASE).
  - Consider total system cost: no need for a frame grabber and lower cabling cost.

✓ Sharp drop in price of frame grabbers over last few years.

Projections for North American Market

Digital Camera North American Market



Source: AIA 2008 MV Market Study

Study Case #1
Camera Aggregation to one PC

- Large number of cameras with very low acquisition rate.
  - Car body inspection in auto industry, 60 cameras triggered simultaneously for exposure, but delayed for image transfer.
  - Takes advantage of the networking capability. Use of Ethernet switches to connect to a single computer.
  - Camera already have on-board memory for Packet Resend logic: useful to implement delayed image transfer.
  - No frame grabber → cost reduction since all cameras go to same PC!

Study Case #2
Control Center

- Centralized control center
  - PCs are not part of the actual system setup: they are centralized in a control center.
  - Inspection Machines are connected through the standard Ethernet. Data is directly sent to control center for analysis.
  - Minimize vibration to PC to reduce downtime. Useful in harsh environment: only camera is exposed.
  - Long cabling required for these applications.

Study Case #3
Image Archiving

- Concurrent Image Processing and Archiving:
  - Customer wants to analyze images, but at same time digitally record them on a second PC.
- Requires data multicasting: camera sends data to 2 destinations
- 2 Receivers for the data stream:
  1. Image Processing PC
  2. Recording PC

Conclusions

GigE Vision is an exciting technology which will expand the automated imaging application base because:

- ✓Cost effective
- ✓Highly flexible system design
- ✓Leverages commercial technology
- ✓Long cable lengths
- ✓Easy expansion

Question and Answers

Thank You!

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