CIP over 6LoWPAN

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Technical Track

Content

A Platform for Innovation

Internet of Things creates huge opportunities

- But often with devices that can't support the cost of an Ethernet and Power Connection

Some problems that sound familiar being solved in homes

- Remotely turning something on and off and monitoring the power?
- Managing the temperature in a vessel?

Marketing must identify the problems

- We need to give them a platform

Promising standard for Field Wireless Sensor Actuator Network

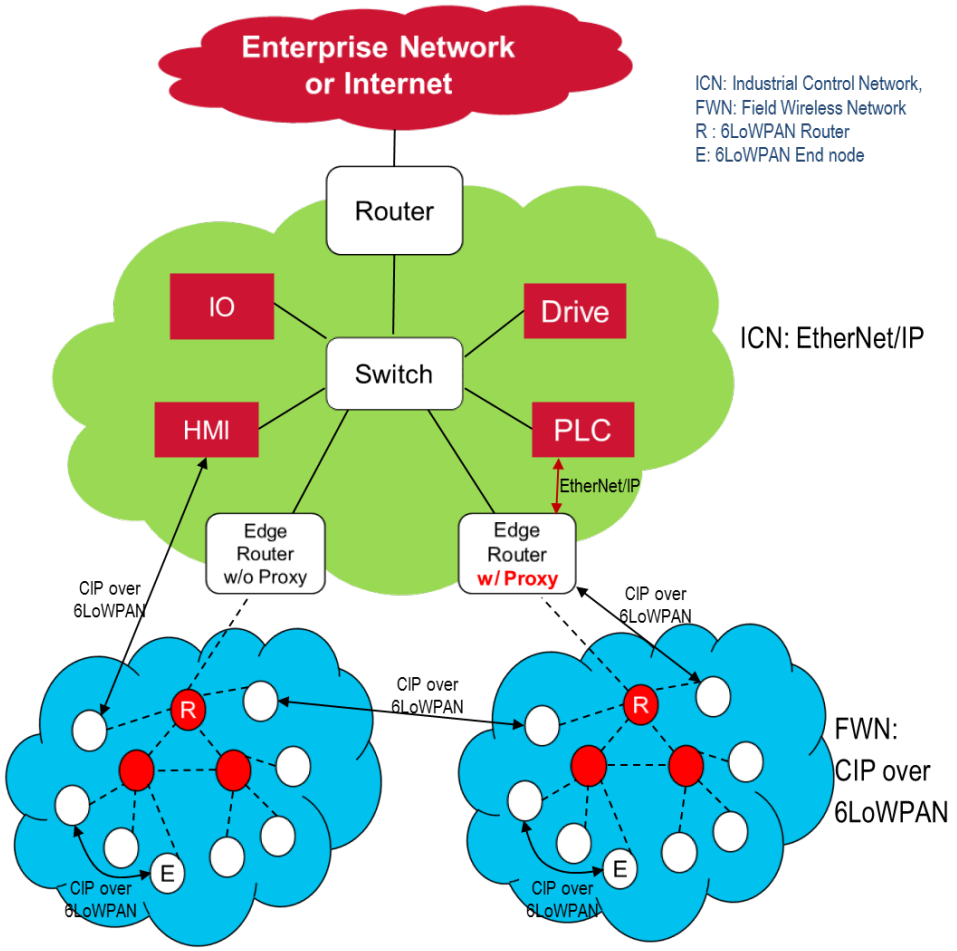
- Good technical alignment with EtherNet/IP

802.15.4

UDP/IPv6

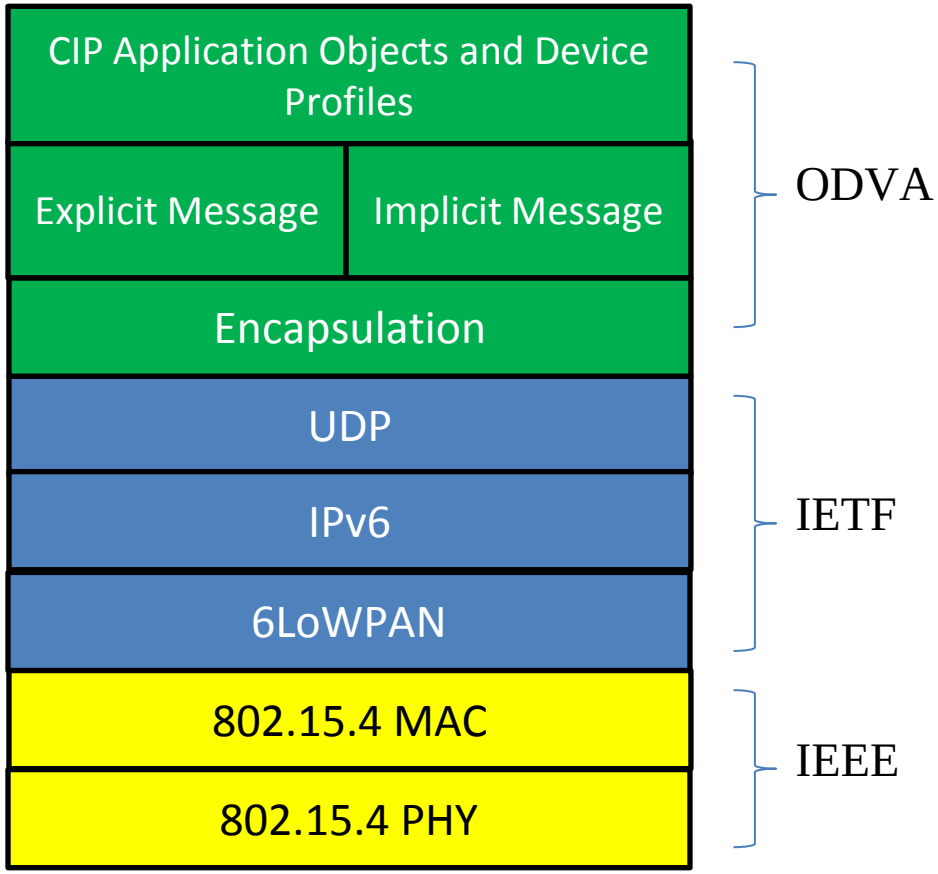
CIP over IP Network Expansion

- IPv6 transition
- Enterprise network convergence
- Field wireless network integration
- Expanded CIP™ network architecture

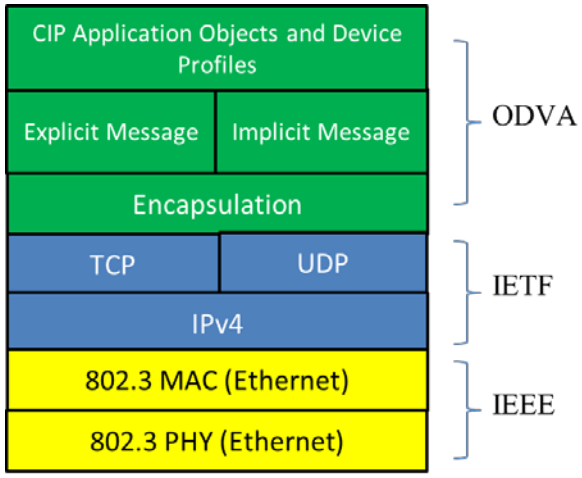


Common Network Stack

CIP over 6LoWPAN?



EtherNet/IP



Requirements and Challenges

6LoWPAN Requirements	EtherNet/IP and CIP's Challenges
IPv6	Not IPv6 ready
UDP-only	TCP for explicit messages
Small packet size (127 bytes PHY payload)	EtherNet/IP assumes larger packet size (1,500 bytes PHY payload)
Limited resources (e.g., second-to-minute level update rate, 128 Kbytes Flash and 32 Kbytes RAM)	CIP and EtherNet/IP assumes there are enough resources (e.g., millisecond level update rate, 256 Kbytes Flash and 128 Kbytes RAM)
Sleep and battery-power	Doesn't consider sleep mode, always mains-powered

Requirements and Challenges (Cont'd)

6LoWPAN Requirements	EtherNet/IP and CIP's Challenges
Peer-to-peer communication among field devices	Difficult to support peer-to-peer communication for field devices due to their limited resources
Security	EtherNet/IP and CIP rely on external security services but do not integrate them
Backward compatibility	How to operate with old CIP devices
Wireless network management (large scale, dynamic topology)	Doesn't consider 6LoWPAN wireless network management

Assumptions

IPv6 Migration of EtherNet/IP completed

- Work ongoing in EtherNet/IP System Architecture SIG
- See Rockwell Automation and Cisco papers

Security

- Work ongoing in EtherNet/IP System Architecture SIG

Both projects will consider the needs of Field Wireless Networks

UDP and TCP in EtherNet/IP

Today, Explicit Messages use TCP and Implicit Messages use UDP

- TCP not generally available in 6LoWPAN
- CIP has its own reliable data transmission checks
  - Transaction ID
  - Typically only 1 outstanding transaction
  - Client Server model for Explicit Messages

Options

- Implement TCP in 6LoWPAN
- **Move to all UDP communications**

Small Packet Size

Ethernet supports a 1500 byte packet; 6LoWPAN supports a 127 byte packet

- 102 byte MAC payload (IP packet + overhead)
- CIP Max packet size 511 bytes + encapsulation
- Typical packet size for target devices 5 – 64 bytes

Options:

- Compress CIP header (Encapsulation Protocol)
  - Increases complexity in end devices
- **Optimize CIP header and limit packet size**
  - Remove unnecessary fields and functions

Limited End Device Resources

Target 128Kb Flash and 32Kb RAM

- Based on available silicon

Remove and optimize backbone centric functionality

- Removal of TCP reduces device load
- Remove session management
  - Relocate revision check
- Remove connected explicit messaging
  - Typically more used at host level today
- Remove bi-directional produce-consume
  - Need marketing analysis
- Remove CIP Routing
  - Need marketing analysis too

Sleep and Battery Power Management

EtherNet/IP assumes permanently powered devices

- No native mechanisms available for adaptation

Considerations:

- Reduce packet size (discussed earlier)
- Make Change of State default communications method
- Develop aggregation method
  - Minimize headers
- Eliminate all polling activities

Backward Compatibility with EtherNet/IP

User experience should be seamless

Network Architecture should be unchanged

Requirements for 6LoWPAN Originators

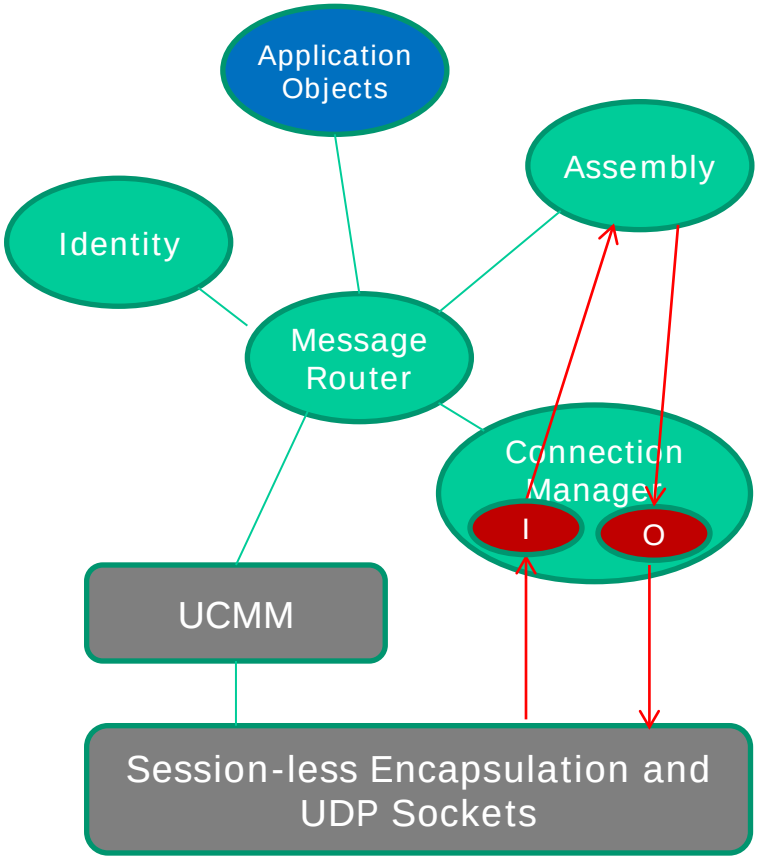
- None – 6LoWPAN target packets will flow through IP Centric Ethernet

Requirements for EtherNet/IP Originators:

- Need to be able to distinguish between packets destined for Ethernet and 6LoWPAN targets
  - Either IANA Port or Protocol Type field in header
- Proxy function needed in gateway to change TCP encapsulation to UDP encapsulation
- Proxy function needed to map EtherNet/IP Produce/Consume (non-trivial)

CIP over 6LoWPAN Stack Features

EtherNet/IP	CIP over 6LoWPAN
IPv4	IPv6
TCP and UDP	UDP only
Session-based encapsulation protocol	Simplified session-less encapsulation protocol
Class 3 and UCMM	UCMM only
Bidirectional Class 0/1 Produce/Consume connection	Simplified unidirectional Produce/Consume connection



CIP over 6LoWPAN Stack Memory Consumption

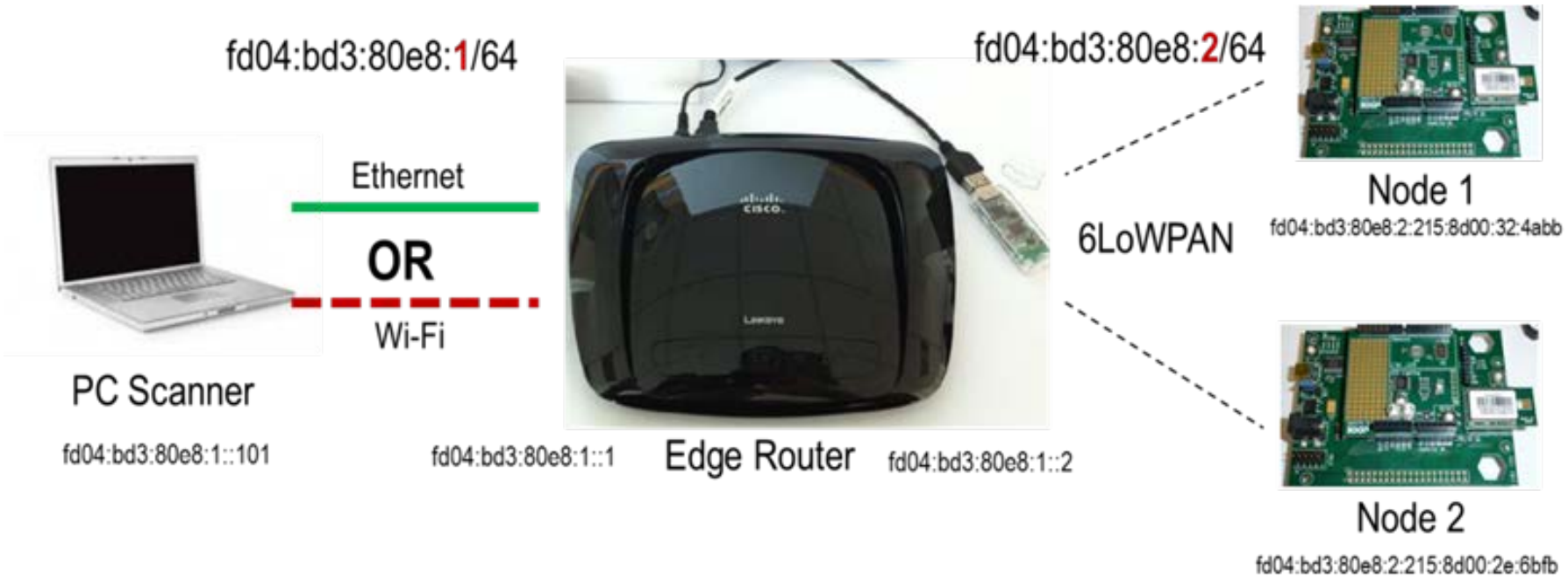
Subsystem	Flash (Byte)		RAM (Byte)	
CIP	12,153	9.27%	1,444	4.41%
6LoWPAN	20,083	15.32%	358	1.09%
JNET[1]	29,549	22.54%	1,216	3.71%
Others (Debug, Storage, etc.)	11,400	8.70%	166	0.51%
Heap	N/A	N/A	10,352	31.59%
Stack	N/A	N/A	4,096	12.5%
Total	**73,185 (71.45K[2])**	**55.83%**	**17,632 (17.22K)**	**53.81%**
Available	**131,072 (128K)**	**100%**	**32,768 (32K)**	**100%**
Left for Application	**57,877 (56.55K)**	**44.17%**	**15.136 (14.78K)**	**46.19%**

1 JNET is a commercial personal area wireless networking and management protocol
2 1 Kbytes is 1024 bytes

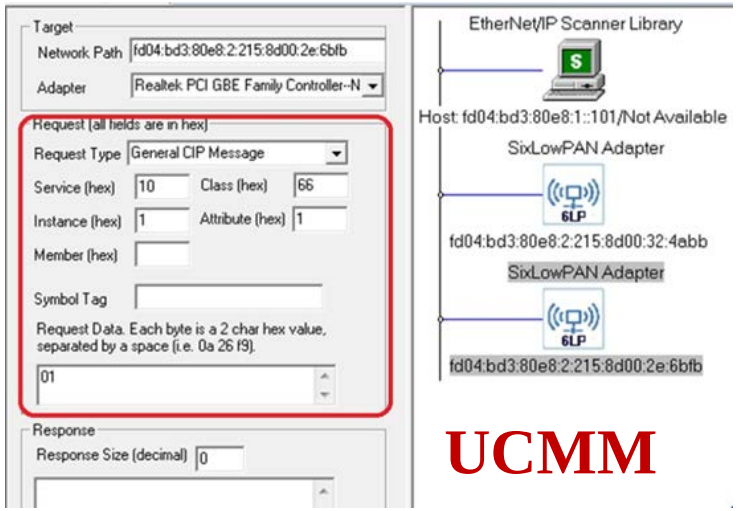
CIP over 6LoWPAN Proof of Concept Platform

CIP over 6LoWPAN in one IPv6 subnet

CIP over Ethernet / Wi-Fi in another IPv6 subnet



CIP over 6LoWPAN Demonstration



UCMM

Dimmable lights

Bulb Object, CLASS Code: 0x66, Instance:1			
Attributes			
ID	Name	Access	Description
1	Mode	SET	Turn On/Off Light
2	State	GET	Light current state
3	Lum_Current	GET/SET	Set bulb brightness
4	Lum_Up	SET	Increase brightness
5	Lum_Down	SET	Decrease brightness
6	Lum_ChangeStep	GET/SET	Set the step for UP and DOWN
7	Op_Cnt	GET	Record the operation count

Application Object: Bulb

Future Work

- Active report
- Network management
- Peer-to-peer communication
- Backward compatibility

Q&A

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