Performance of SpaceWire Plug-and-Play Protocols

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Overview

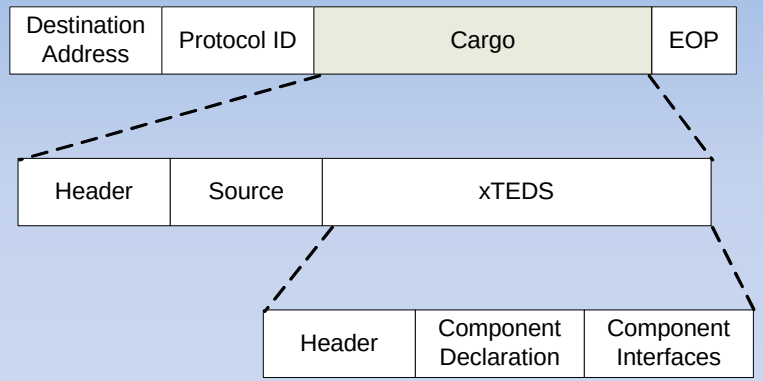
- Plug-and-Play (PnP) describes a mechanism by which devices can be discovered and configured automatically to be ready for use soon after they are inserted into a system
- Two different standards have emerged which provide Plug-and-Play support for SpaceWire networks
  - Space Plug-and-Play Architecture (submitted to AIAA)
  - SpaceWire-PnP (submitted to ECSS)

Terminology

- SPA/SPA-S
  - SPA – Space Plug-and-Play Architecture
    - formerly Space Plug-and-Play Avionics
  - SPA-S – SPA SpaceWire Subnet
  - SSM/SSI – SPA Services Manager/Infrastructure
    - replaces and expands upon the Satellite Data Model
  - CAS – Central Addressing Service
  - SPA-L – SPA Local Interconnect
  - SM-s – Subnet Manager for SpaceWire
  - xTEDS – Extensible Markup Language Transducer Electronic Data Sheets
  - UUID – Universally Unique ID
- SpaceWire PnP
  - RMAP – Remote Memory Access Protocol
  - Active Node – a node which can initiate protocol commands
  - Passive Node – a node which can receive and respond to protocol commands
  - Level 1 Networks – have only one active node
  - Level 2 Networks – can have more than one active node

Messaging

- SPA-S uses SPA messaging
  - Component Information described by xTEDS
- SpaceWire PnP uses subset of RMAP messaging
  - Targets include standard parameters for Device Identification



First byte transmitted

	Target SpW Address	....	Target SpW Address
Target Logical Address	Protocol Identifier	Instruction	Key
Reply Address	Reply Address	Reply Address	Reply Address
Reply Address	Reply Address	Reply Address	Reply Address
Reply Address	Reply Address	Reply Address	Reply Address
Initiator Logical Address	Transaction Identifier (MS)	Transaction Identifier (LS)	Extended Address
Address (MS)	Address	Address	Address (LS)
Data Length (MS)	Data Length	Data Length (LS)	Header CRC
Data	Data	Data	Data
Data	...	...	Data
Data	Data CRC	EOP	

Last byte transmitted

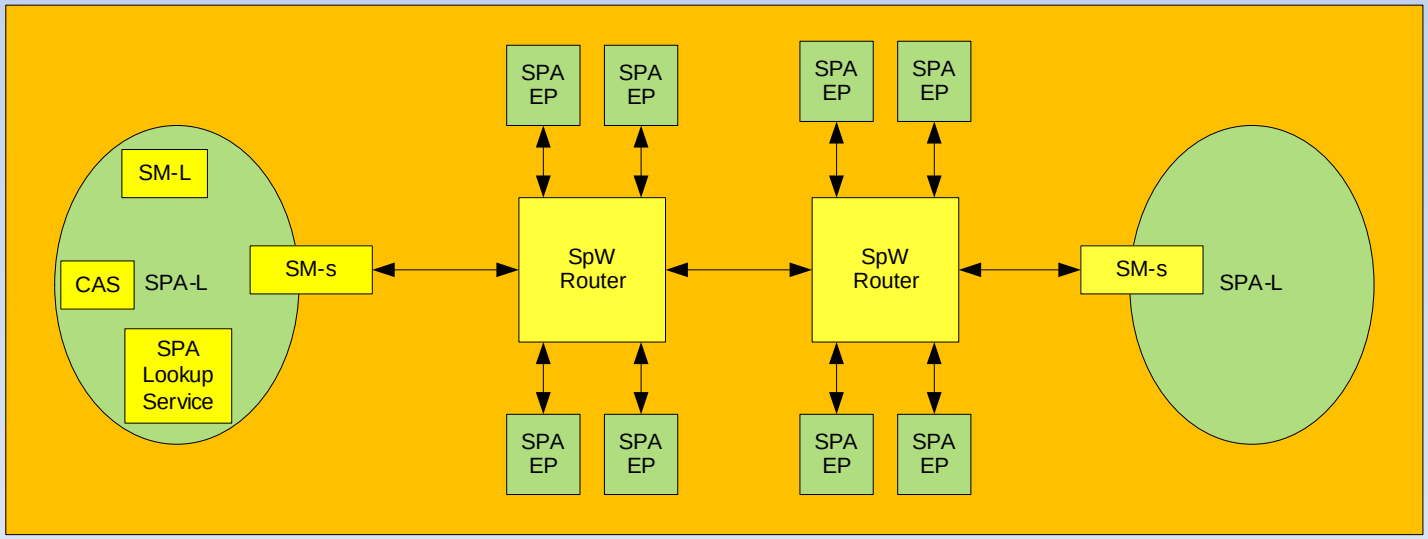
1 - Figure from ECSS-E-ST-52C, February 2010

Services

- SPA/SPA-S
  - Topology Discovery
  - SPA Packet Routing
    - Subnet manager keeps a routing table which converts from SPA logical addresses to SpW path addresses
    - SPA logical addresses are not SpaceWire logical addresses
- SpaceWire PnP
  - Device Identification
  - Network Configuration
  - Link Configuration
  - Router Configuration
  - Time-Code Source
- Two levels of service
  - Level 1 – Managed Networks (1 active node)
  - Level 2 – Open Networks (more than 1 active node)

SPA/SPA-S Example

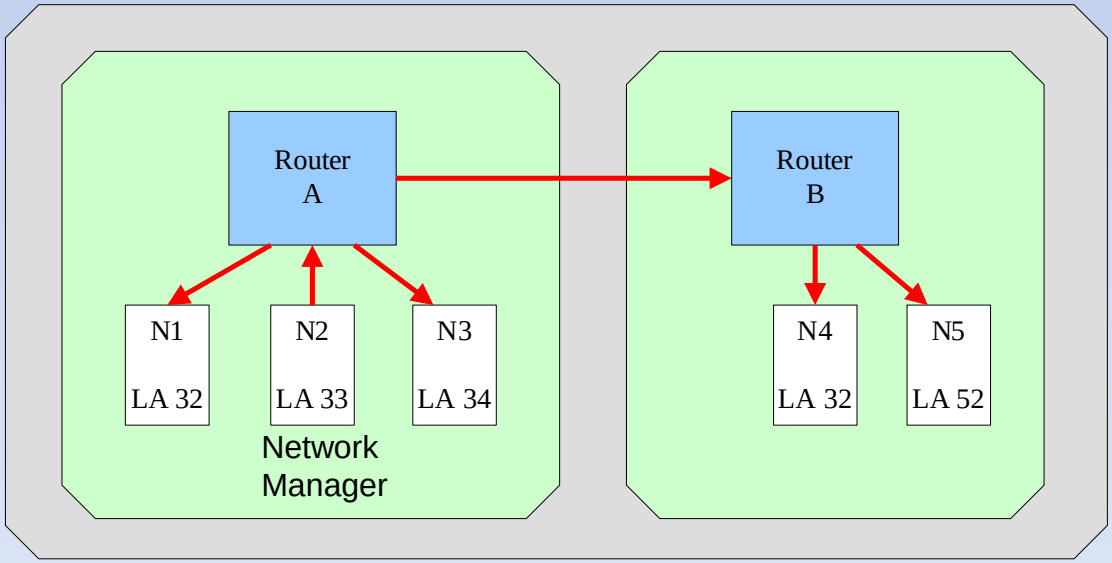
- SpaceWire Subnet Managers (SM-s) independently discover the paths to network endpoints
  - SPASpaceWireRouterProbe used to interrogate routers
  - SPASpaceWireEndpointPing used to find ports where endpoints are attached
  - SM-s requests a block of SPA logical addresses from the Central Addressing Service and uses this information to route packets to components
  - Under SPA, components register with a Lookup Service in order to make services available



2 - Figure from DRAFT AIAA SPA-S Standard

SpaceWire PnP Example

- A Network Manager queries devices by using a breadth-first traversal.
  - Messages are sent to the configuration port (port 0) of each device in order to identify capabilities.
  - Device Identification provides some information
    - the number of active ports available for a device (can be used to determine if this a router)
    - the port used to send the reply



Performance

- Network discovery for both SPA-S and SpaceWire-PnP depend on a breadth-first search algorithm. Each network manager or active node must search the entire subnetwork. Thus, expected performance is *O(N +L)*, where *N* is the number of nodes on the network and *L* is the number of links.
- For both protocols, specific timing requirements have not been levied on devices. This makes comparison of timing between the protocols difficult without evaluating particular implementations.
  - Experimental research is needed to realistically evaluate performance.

Performance

- Performance will be influenced by several implementation factors:
  - Device Protocol Support
    - Since the message format for SpaceWire-PnP is based on RMAP, many devices today that support RMAP could be adapted to also support SpaceWire-PnP. Hardware support would improve speed.
    - To comply with SPA-S, an end node must only keep a routing path to a Subnet Manager (SM-s). Nevertheless, since routing messages through the SM-s can overload it, it is desirable for end nodes to cache routes to other nodes that they communicate with often.
  - Network Topology
    - A larger network will take longer to map than a smaller one. Timing delays for an Open Network will be less controlled than for a Managed Network.

Advantages

- SPA/SPA-S
  - (SPA-S) Integrates well with SPA
  - Provides an integrated set of services that is independent of transport
  - Processing elements required to parse and make use of xTEDs messaging
- SpaceWire PnP
  - Integrates well with SpaceWire Protocol Stack
  - Leverages existing development for RMAP protocol
  - Provides support for Link and Router Configuration

Disadvantages

- SPA/SPA-S
  - Network Discovery takes a bit more time because the protocol does not take advantage of device identification
  - Does not include facilities for link and router management
  - Routing through the SM-s limits throughput
- SpaceWire PnP
  - Does not provide native provisions for registering device services
    - Could potentially also use xTEDS
  - Imposes some requirements on devices
    - Some legacy devices may not be compatible
  - RMAP timing requirements limit size of network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Questions?

References

1. ECSS-E-ST-50-12C, Space Engineering: SpaceWire – Links, nodes, routers, and networks", ESA-ESTEC, July 2008.
2. "Space Plug-and-Play Architecture Standard – SpaceWire Subnet Adaptation," American Institute of Aeronautics and Astronautics, 2010, *DRAFT*.
3. Mendham, P., Florit, A. F., and Parkes, S., "Spacewire-PnP Protocol Definition," Space Technology Centre, University of Dundee, September 16, 2009, *DRAFT A, Issue 2.1*.