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

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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
Questions?
