Application of the SpaceWire Plug-and-Play Protocol

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Introduction

- The proposed SpaceWire Plug-and-Play (SpaceWire PnP) protocol provides an infrastructure for network management
  - Discovery of arbitrary network topologies
  - Configuration of device parameters to establish communication
  - Timely detection of changes to the network
- The SpaceWire PnP protocol defines a set of common parameters and behaviors to facilitate recognition of and interaction between devices
  - Allows various network management approaches
  - Includes mechanisms for arbitration between multiple network managers
  - Supports both polled and asynchronous notification of changes to the network
  - Provides access to device configuration parameters

Outline

- Overview of the SpaceWire PnP Protocol
  - Data Types and Parameters
  - Packet Types and Behaviors
  - Special Considerations
- Network Management
  - Network Discovery
    - Device Recognition
    - Identity Resolution
    - Topology Mapping
    - Dynamic Network Changes
  - Network Configuration
    - Configuration Resources
    - Conflict Resolution

Overview of the SpaceWire PnP Protocol

- Purpose
  - Provide facilities for network management
    - Specifically, device discovery and configuration
  - Identify and configure SpaceWire PnP-compatible devices
    - Exchange packets (Read, Response, Write, Reset and Notification) between network managers and network elements
    - Each packet is tailored to an operation by the associated data type
- Philosophy
  - Minimize constraints on higher-level network manager functionality by leaving complex behaviors to software
  - Example:
    - Write and Reset transactions do not include acknowledgement packets, so a follow-up Read transaction is necessary to confirm success

SpaceWire PnP Data Types and Parameters

- Data types are predefined combinations of parameters
  - Used as cargo in SpaceWire PnP packets
  - Each serves a specific Plug-and-Play application
- Parameters identify characteristics or control behavior of SpaceWire PnP devices
  - Defined by ECSS-E50-12A and the SpaceWire PnP draft
  - Six categories
    - Device
    - General Use
    - eXtended Transducer Electronic DataSheet (xTEDS)
    - Network Discovery
    - Event Notification
    - Network Configuration
  - Minimum set mandatory, others optional

SpaceWire PnP Data Types and Parameters

- Read-only parameters
- xTEDS File is optional

		Data Type													
		Device Description	Active Ports	Device Identifier	Valid Logical Addresses	Arbitration Mode	Port Table Entry	Link Speed Table Entry	Routing Table Entry	Network Manager Identification	Notification Table Entry	Detachment Timeout	Notification Information	xTEDS File	Error	Return Address (implicit)
Device Parameters (Read-Only)																
Parameters	Device Class	√														
	Vendor Identifier	√														
	Subsystem Identifier	√														
	Version	√														
	Ports	√														
General Use Parameters (Read-Only)																
	Incoming Port Number	√														
	Active Ports	√	√										√			
xTEDS Parameters (Read-Only)																
	xTEDS File													√		

SpaceWire PnP Data Types and Parameters

- Read/write
- All except Device Identifier are router-only
- Event Notification parameters are optional

		Data Type													
		Device Description	Active Ports	Device Identifier	Valid Logical Addresses	Arbitration Mode	Port Table Entry	Link Speed Table Entry	Routing Table Entry	Network Manager Identification	Notification Table Entry	Detachment Timeout	Notification Information	xTEDS File	Error	Return Address (implicit)
Network Discovery Parameters (Read-Write)																
Parameters	Device Identifier	√		√												
	Granted Port Number									√						
	Network Manager Logical Address									√						
Event Notification Parameters (Read-Write)																
Parameters	Detachment Timeout											√				
	Notification Table Size	√														
	Notification Table Entry – Acknowledgement Timeout										√					
	Notification Table Entry – Router Identifier										√		√			
	Notification Table Entry – Notification Address										√					

SpaceWire PnP Data Types and Parameters

- Read/write
- Valid Logical Addresses, Arbitration Mode and Arbitration Priority are optional

		Data Type														
		Device Description	Active Ports	Device Identifier	Valid Logical Addresses	Arbitration Mode	Port Table Entry	Link Speed Table Entry	Routing Table Entry	Network Manager Identification	Notification Table Entry	Detachment Timeout	Notification Information	xTEDS File	Error	Return Address (implicit)
Network Configuration Parameters (Read-Write)																
Parameters	Logical Address	√			√											
	Valid Logical Addresses				√											
	Arbitration Mode					√										
	Port Table Entry – Arbitration Priority						√									
	Port Table Entry – Link State						√									
	Port Table Entry – Link Status						√									
	Port Table Entry – Link Speed							√								
	Port Table Entry – Maximum Link Speed							√								

SpaceWire PnP Data Types and Parameters

- Read/write
- Router only
- Arbitration Priority and Packet Distribution are optional

		Data Type													
		Device Description	Active Ports	Device Identifier	Valid Logical Addresses	Arbitration Mode	Port Table Entry	Link Speed Table Entry	Routing Table Entry	Network Manager Identification	Notification Table Entry	Detachment Timeout	Notification Information	xTEDS File	Error	Return Address (implicit)
Network Configuration Parameters (Read-Write)																
Parameters	Routing Table Entry – Port Association								√							
	Routing Table Entry – Header Deletion								√							
	Routing Table Entry – Arbitration Priority								√							
	Routing Table Entry – Packet Distribution								√							

SpaceWire PnP Packet Types and Behaviors

- Read packet type
  - Requests a response containing a specified data type
- Response packet type
  - Includes either the requested data type or the Error data type
- Write packet type
  - Conditionally writes the included data type
    - Each writable parameter associated with the identified data type must contain the default value
- Reset packet type
  - Unconditionally resets the data type identified
    - Each writable parameter associated with the identified data type is initialized to the default value
- Notification packet
  - The router sends the Notification Information data type to the network address contained in an active Notification Table entry

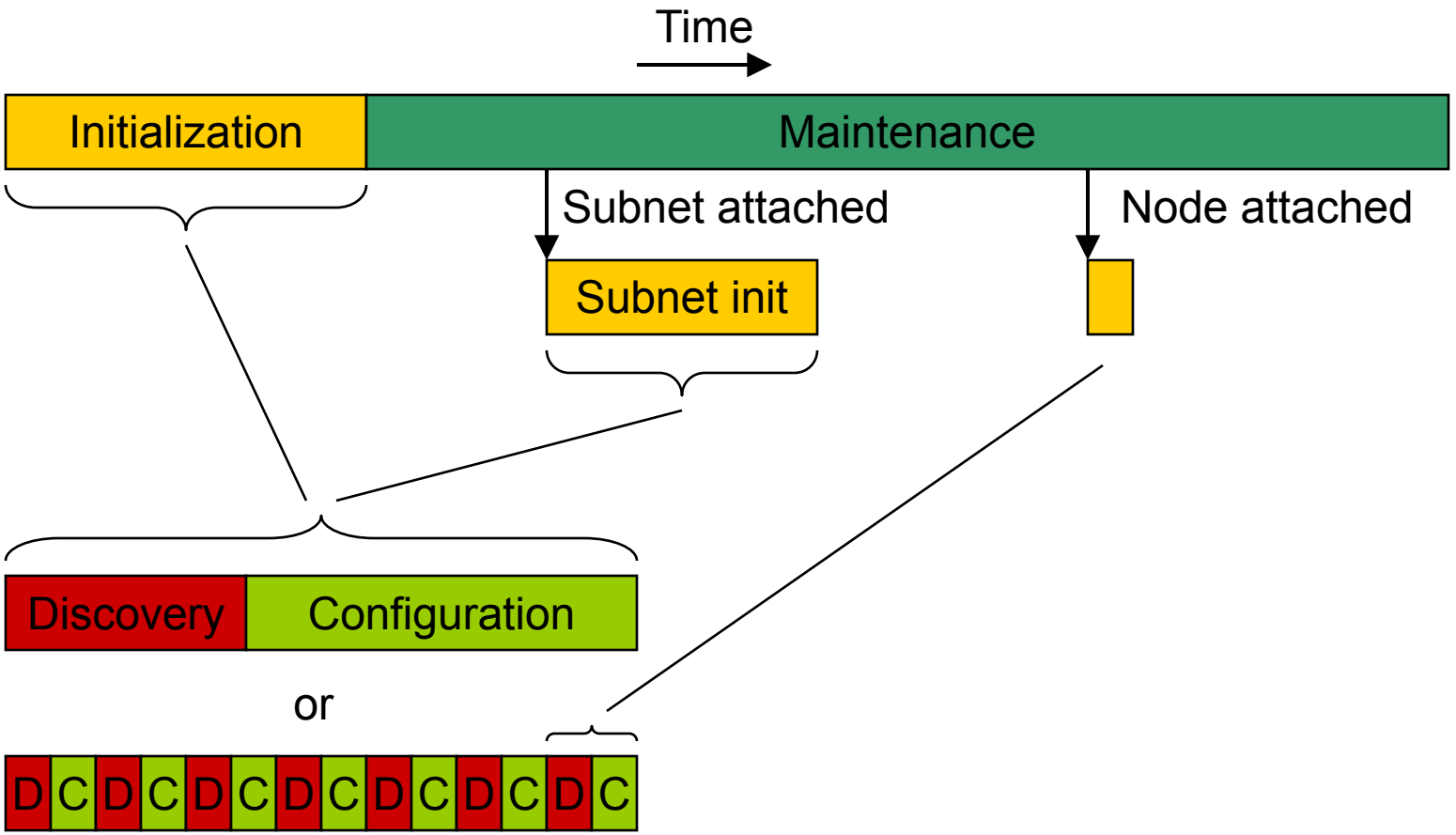
SpaceWire PnP Special Considerations

- Network discovery requires interaction with network elements of unknown type (either routers or nodes)
- ECSS-E50-12A defines path 0 as the standard mechanism for interacting with routers
  - There is no standard mechanism defined for interacting with nodes
- SpaceWire PnP defines path 0 as the mechanism for interacting with SpaceWire PnP network elements (both routers and nodes)
- Since other SpaceWire protocols based on ECSS-E-50-11 Protocol Identification (e.g., RMAP) have the same problem, the universal acceptance of packets with a leading path 0 address should be established by the ECSS-E-50-11 Protocol Identification standard

Network Management

- Initialization phase
  - The initial network functionality is limited to the ad-hoc automatic initialization achieved by the network elements
    - Network topology unknown
    - Network elements unidentified
  - Full network discovery and configuration
    - Build network database (topology and element information)
- Maintenance phase
  - The network has reached steady-state conditions with occasional disturbances
    - Detachments
    - Attachments
  - Detachments may require re-configuration at network boundary
  - Attachments require discovery and configuration
    - Nodes
    - Subnets

Network Management



Network Discovery

- Explore the network
  - Identify each network element encountered
  - Map the connections between the network elements
- The SpaceWire PnP protocol provides the tools
  - The SpaceWire PnP parameters (Device, General Use, xTEDS, Network Discovery and Event Notification) are all designed to aid network discovery
- Implementation of search algorithms is left to higher-level network manager applications

Network Discovery – Device Recognition

- Device recognition involves two aspects of device identity
  - The characteristics of the device (e.g., this device is a SpaceWire PnP router with eight ports)
    - Established by the Device Description data type
  - The name of the device (e.g., this is SpaceWire PnP router 25)
    - Established by the Device Identifier data type
- The device name must be unique so the network topology can include multiple indistinguishable devices with identical characteristics
  - Pre-assigned in hardware
  - Assigned by a single network manager
  - Assigned by multiple network managers each using a unique name space (non-overlapping)

Network Discovery – Identity Resolution

- Critical when multiple network managers are discovering the network
  - Each assigns a locally unique name to each network element
  - Another network manager may assign the same name to a different network element
- In the absence of pre-established namespaces, the network managers must communicate to resolve naming collisions
  - The SpaceWire PnP Network Manager Identification parameters provide facilities to aid network manager communication
    - The Granted Port Number indicates the router port that starts the path address to the network manager that claimed the router
    - The Network Manager Logical Address provides the logical address of the network manager that claimed the router

Network Discovery – Topology Mapping

- Builds a database (a map) of the network connections
- Each network entity and its interconnections are uniquely identified such that all paths between any two network elements are known
  - Critical for assembling path addresses between two nodes of a SpaceWire network
  - Critical for addressing SpaceWire routers
    - SpaceWire routers do not have logical addresses
  - Necessary for configuring the routing table in each SpaceWire router

Network Discovery – Dynamic Network Changes

SpaceWire PnP

- The network topology changes when a network element (a single node or a subnet) is attached or detached
  - Attachment – The new network region must be mapped and configured (or reconfigured) to merge it with the existing network topology
  - Detachment – The network topology must be pruned to the new boundary
- SpaceWire PnP supports network change detection by polling or event notification
  - Polling requires periodic scanning of the entire network
    - Detection latency determined by scan interval
    - Network traffic determined by network size and scan frequency
  - Event notification requires router support
    - Immediate notification minimizes latency
    - Network traffic is two packets per event per network manager

Network Configuration

- Tailors the network to the needs of the application
  - Unnecessary when all links autostart and logical addressing is not used
- Supports optional features defined by ECSS-E50-12A
  - Link management
  - Logical addressing
  - Group adaptive routing
  - Packet distribution
  - Routing arbitration
- Supports the new features of SpaceWire PnP
  - Event notification
  - Device identification
  - Network manager communication

Network Configuration – Conflict Resolution

- Necessary when multiple network managers are attempting to configure the same network element
  - Must be implemented by higher-level network manager applications
- SpaceWire PnP includes facilities to aid in conflict resolution
  - Conditional-write behavior enforces serial access to parameters
  - Network Manager Logical Address parameter
    - Can be used to indicate the network manager than owns the device
    - Supports communication between network managers to resolve configuration conflicts
      - Partition network into non-overlapping regions of responsibility
      - Negotiate non-overlapping roles of responsibility
        - » Establish unique device identities
        - » Initialize routing tables

Conclusion

- The SpaceWire PnP protocol defines capabilities that support discovery and configuration of a network of compatible devices
  - Based on a philosophy of providing basic facilities and leaving as much behavior to higher-level network manager applications as possible
  - The SpaceWire PnP packets and behaviors are transparent to legacy SpaceWire routers (except when addressed to a legacy router)
- Support is included for standard SpaceWire and new Plug-and-Play features
  - Most features defined by the ECSS-E50-12A SpaceWire standard are explicitly supported
  - The Plug-and-Play features address device identification, network manager communication and event notification, all critical to network discovery and maintenance
- Contention resolution between multiple active network managers is addressed, but the details are left to higher level applications
- Some features are optional to facilitate development of minimal products

References

- SpaceWire Plug-and-Play Specification: SpaceWire PnP Draft A 2007Aug16 http://tech.groups.yahoo.com/group/SpaceWirePnP/files/Draft%20Specification/
- SpaceWire Specification: http://spacewire.esa.int/content/Standard/ECSS-E50-12A.php
- SpaceWire Protocol ID Draft Specification: http://spacewire.esa.int/content/Standard/Draft_ECSS-E50-11.php