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An Application in Technology Insertion for a Legacy System

Nathan Adams - nathan.adams@gtri.gatech.edu
Jimmy Simmons - jimmy.simmons@gtri.gatech.edu

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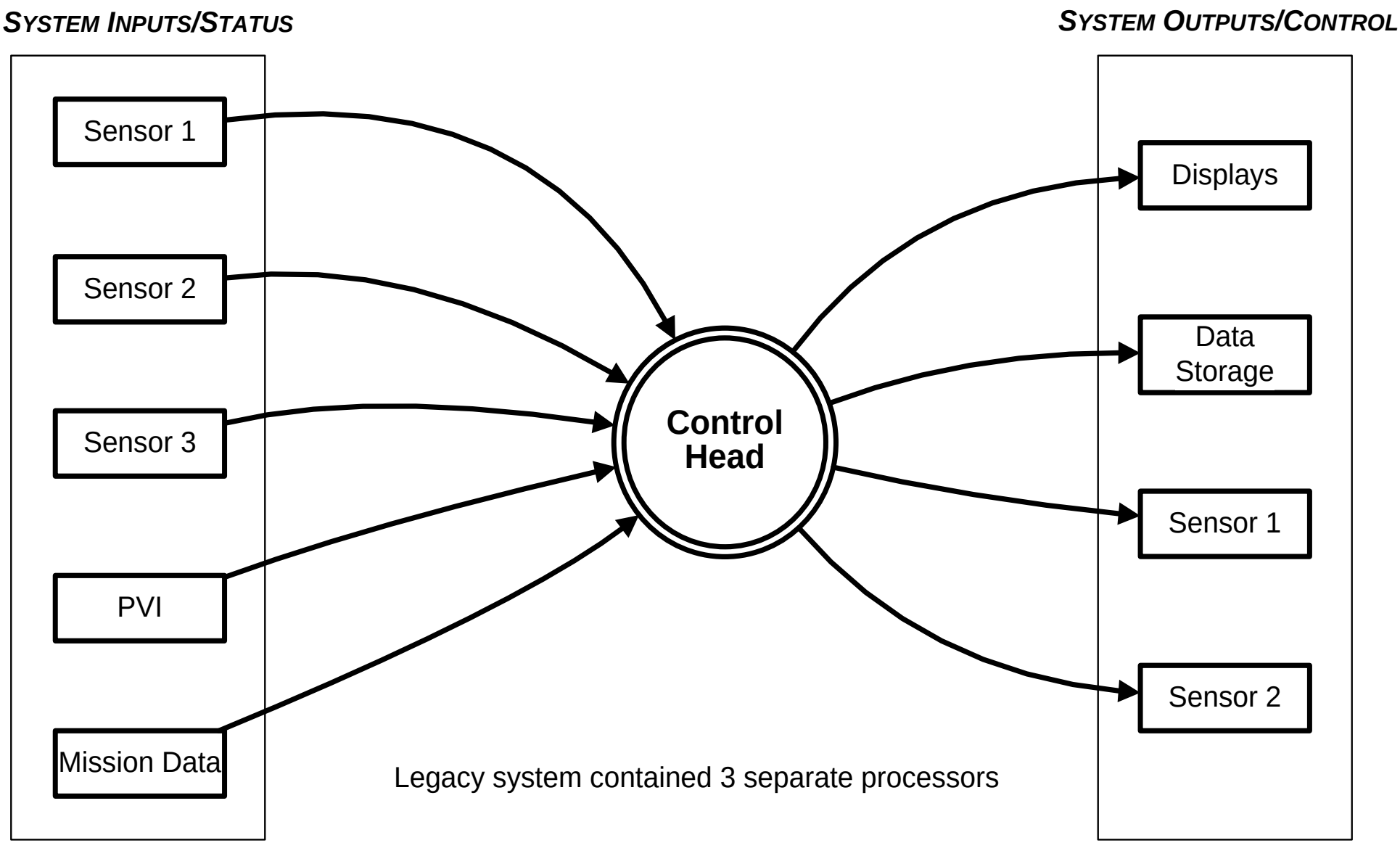
Topics

- Legacy System Overview
- Legacy System Limitations
- Software Port
- Adding New Interface
- Support Tools

Legacy System Overview



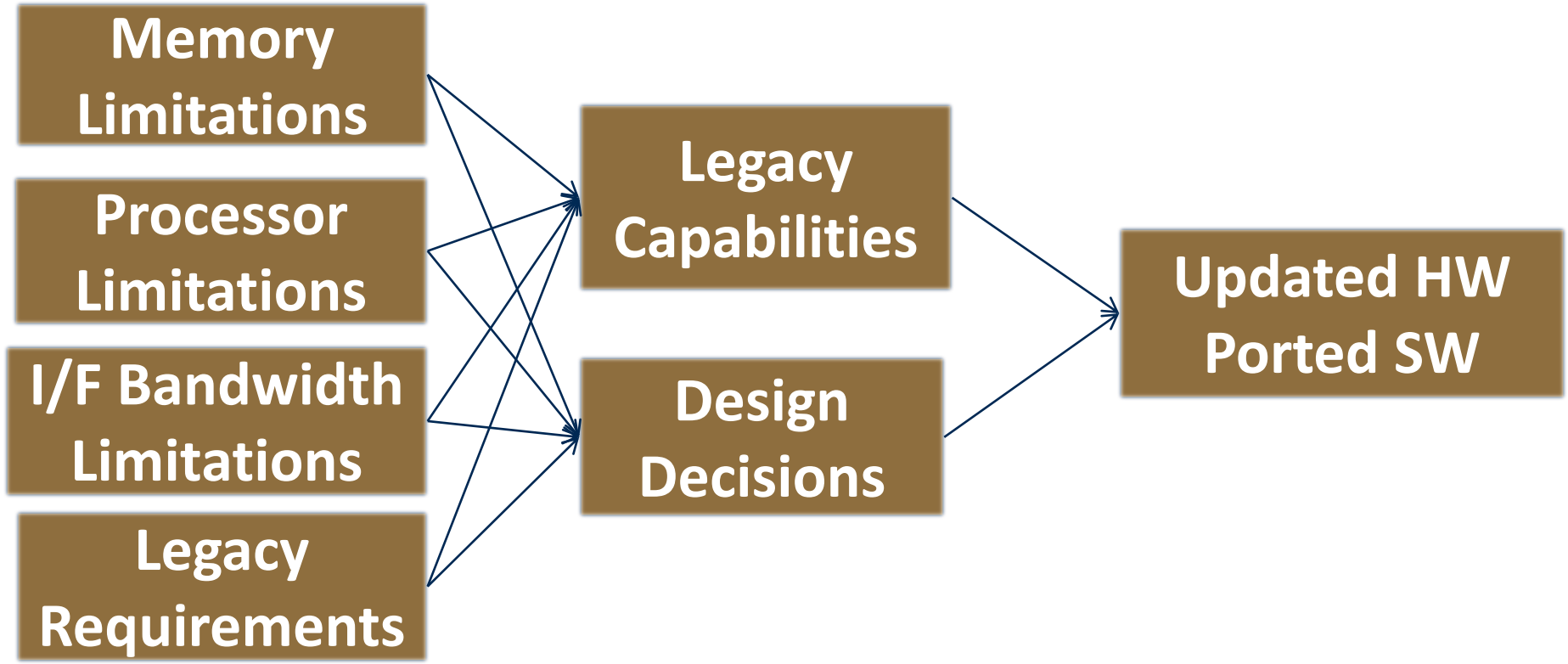
Legacy system contained 3 separate processors

Legacy System Limitations

- Single software build could not longer support multiple aircraft creating substantial sustainment cost increase
  - Processor memory/throughput could not sustain single OFP, resulted in split development paths
- Reached Processor limitations
- Diminishing Manufacturing Sources (DMS)
- External I/O bandwidth restrictions
- Engineering limitations and cost led to the desire to upgrade the legacy system

Legacy System Limitations

Design Constraints



Legacy System & Design Constraints

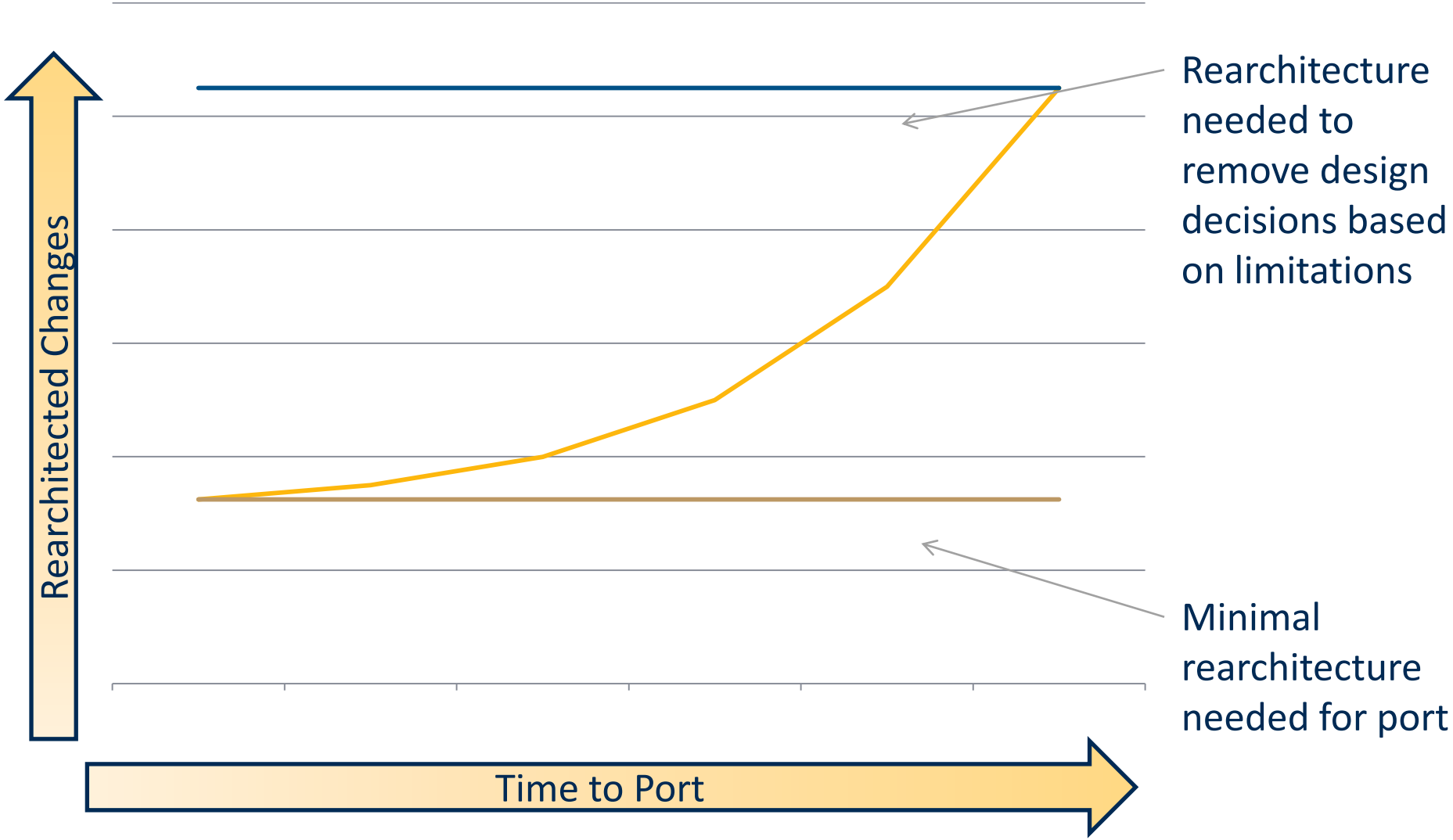
- Hardware updates included:
  - Replaced (3) legacy Processors with single more powerful Processor
  - Additional Memory
  - FPGA for Data I/O
  - Ethernet Interface for Growth
- New Processor decisions limited by legacy heat and power constraints
- Most software design decisions focused on minimal effort to port the legacy functionality to new hardware due to cost and schedule constraints

Software Port

- With schedule constraints, temptation to focus on fastest solution with minimal effort
- Care must be taken to evaluate potential future requirements and how to incorporate that into design
- For this system, forward looking design decisions included:
  - Detecting the required version at runtime, this allows for fewer development paths and lower sustainment cost
  - Massaging data from the external interfaces to appropriate software modules
  - Passing data through consistent internal interfaces

Software Port

Notional Chart: Rearchitected Changes versus Time to Port



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Selection of real-time operating system (RTOS)

- VxWorks 653
  - Certified space and time partitioning
  - Setup more complex than 6.x
  - Used by engineers in previous project
- VxWorks 6.x
  - User managed time partitioning
  - Setup less complex
- Green Hills Integrity
  - Fewer engineers had experience with this RTOS
- Hardware Vendor Proprietary RTOS
- VxWorks 653 was chosen based on the partitioning aspect and engineering experience from previous projects

Software Port

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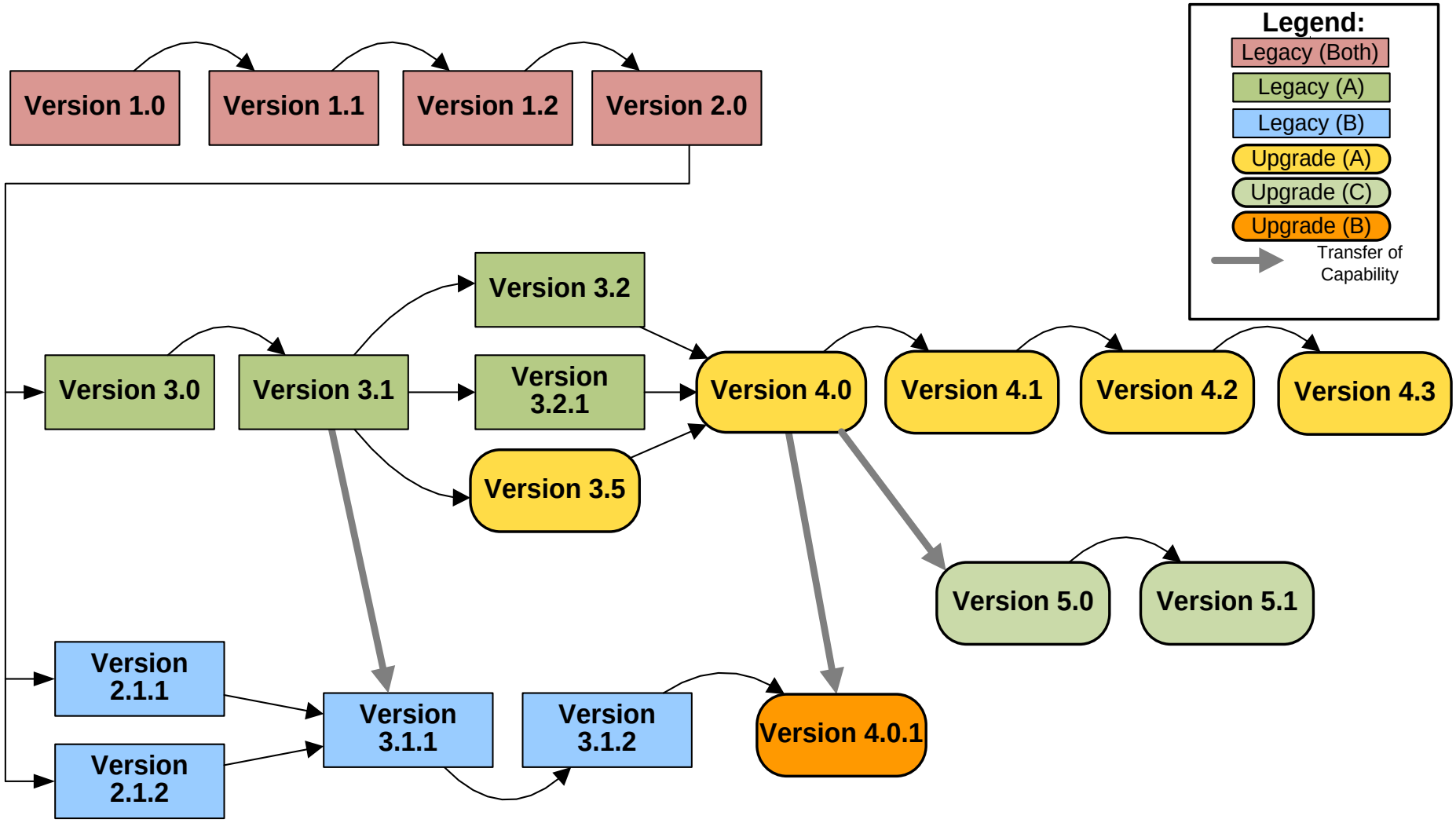
SW Port based on Tight Schedule Constraints While Designing for Future Growth:

- One legacy processor ported directly to one of the new RTOS partitions
  - Later split into (2) partitions based on functionality
- Second legacy processor was split in to three partitions based on different functionalities as well
  - Another option was to use a single partition, but for future growth splitting the functionality was preferred
- Third legacy processor was ported to a soft-core processor on an FPGA, no software changes were required!
  - Another option was to port the functionality to another partition, but scheduling constraints were the limiting factor

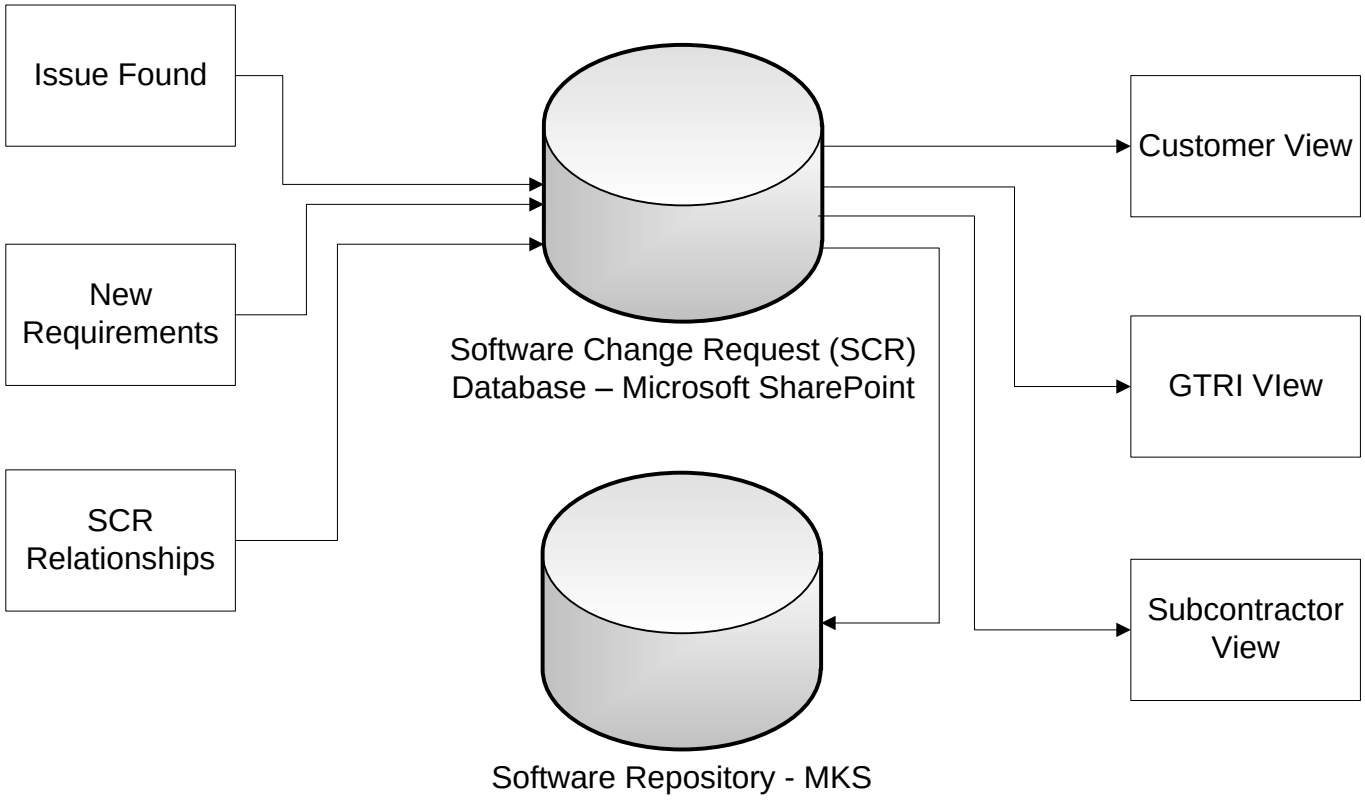
Software Port

- Decisions Going Forward
  - Parallel Support for Upgraded and Legacy System
  - Effects of Adding New Interface
  - Legacy Support Tools

Parallel Support



Parallel Support Solution

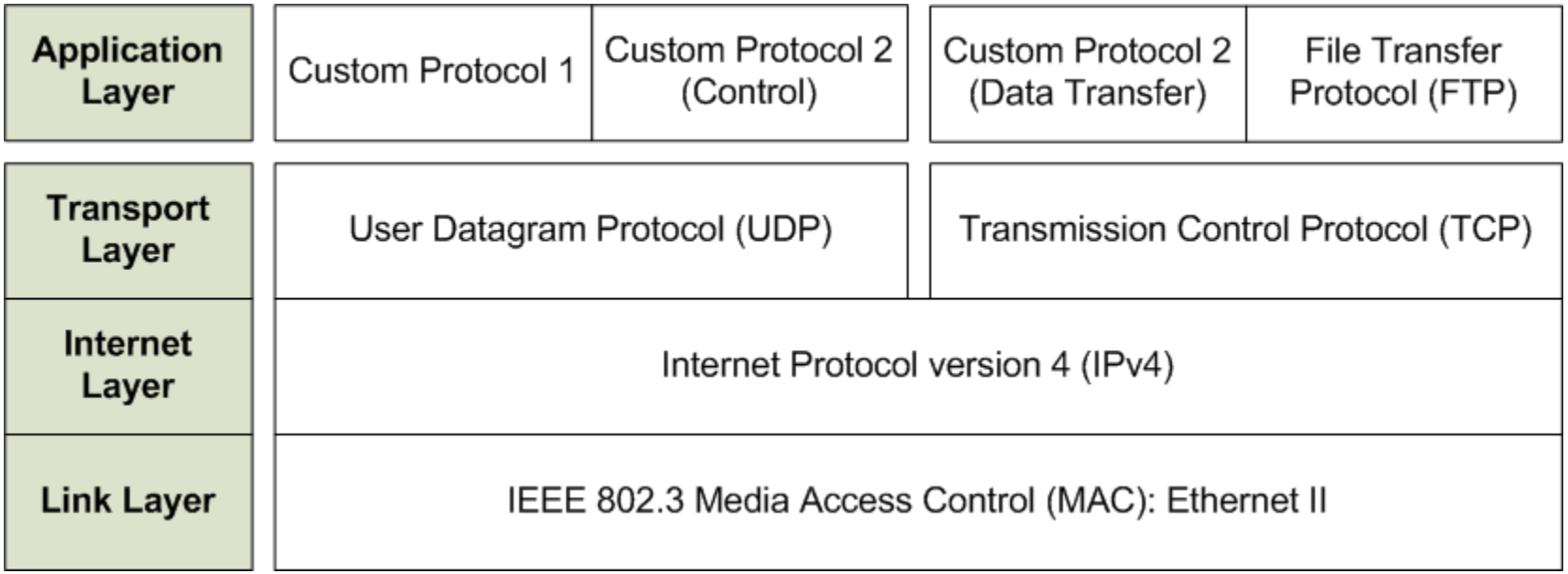


Adding New Interface

- Initial interfaces were designed for loosely coupled systems, i.e. not much information exchange
- As the systems became less federated in the associated system of systems, interface bandwidth became a limiting factor for requirements
- MIL-STD-1553B primary data bus for legacy system
  - Small message size, 64 bytes
  - Slower data rate, 1 Mbit/s
  - Requires specialized and increasingly obsolete hardware & software tools
- 10/100 Ethernet interface added
  - Max 65 Kbyte per message
  - 100 megabits per second data rate
  - Ubiquitous hardware and plethora of software tools

Adding New Interface

- TCP and UDP chosen as transport layer protocols
- Application layer protocols
  - Tradeoffs exist between proprietary protocols and older vetted protocols
  - Ultimately File Transfer Protocol (FTP) and two custom / application specific protocols were chosen



Support Tools

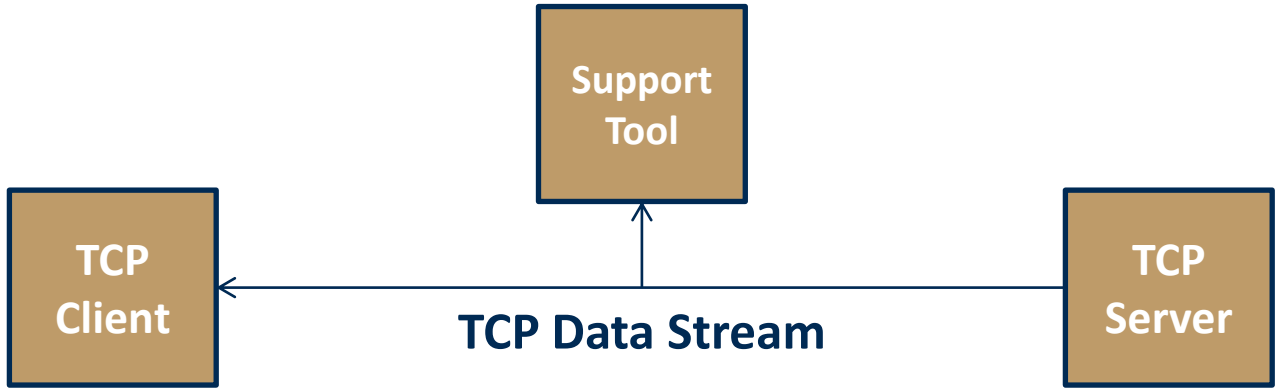
- Legacy tools based on MIL-STD-1553B messaging
  - Commercial Off the Shelf (COTS) bus analyzers
  - Custom in-house applications
    - Graphical displays for monitoring message traffic
    - Simulation application for messages to Control Head
    - Support for playback of recorded flight-test data files
- Design decision had to be made to add new interface support to old tool or design a new tool
  - Using old tool meant both simulation and analysis with a single tool, but subject to design decisions made for legacy interface
  - Creating new tool means multiple tools have to be supported, but allows for fresh start for design

Support Tools

- Updated and new tools for Ethernet based messaging
  - Opensource TCP/IP sniffing application
    - Wireshark: http://www.wireshark.org/
  - Custom in-house applications
    - Desire to see MIL-STD-1553B and Ethernet messages co-mingled for system level analysis
    - Next generation monitoring application that supports arbitrary number of messaging protocols
    - Update simulation application to support Ethernet messaging
    - Support for variety of file formats
      - IRIG 106 Chapter 10 (MIL-STD-1553B and Ethernet)
      - Firefly (MIL-STD-1553B only)
      - PCAP (Ethernet only)

Support Tools

- **Challenges with monitoring Link Layer (Ethernet) traffic**
  - **Must first decode Link, IP, and Transport Layer in order to decode Application Layer data**
  - **Must handle reassembly of fragmented packets at IP Layer**
  - **Must handle segmentation of TCP streams**
    - **No inherent way for 3rd party observer (e.g. support tool) to know where you are in the data stream!**
      - **Unless you start recording before the TCP connection is *made (not likely or guaranteed in real world)***



Support Tools

- Decision to re-work TCP-based application layer protocol to better accommodate test and evaluation tools
  - Lesson Learned: Consider test & evaluation up-front during interface design
- Legacy simulation application had many MIL-STD-1553 specific assumption embedded in design and implementation
  - Re-architected to better support multiple messaging protocols
  - Lesson Learned:
    - Software reuse is not free
    - Cost & schedule trade for new capabilities

Summary

- Legacy system sustainment is a challenge
- Technology insertion alleviated the system exhaustion but came with various hurdles
- Hardware replacement and SW port is only part of the solution, support tools also must be considered
- By the time new system fields, not unusual for system exhaustion to be at the forefront again!

Questions?

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