A Performance Modeling and Simulation Approach to Software Defined Radio

OMG Software-Based Communications (SBC) Workshop
San Diego, CA - August, 2005

Shawkang Wu & Long Ho
Integrated Defense Systems
The Boeing Company
Anaheim, CA

BOEING®

Typical M&S Approach

- Define problem
- Collect and analyze input sources
- Develop, verify, and validate model
- Define scenarios and conduct simulations
- Analyze outputs and draw conclusions

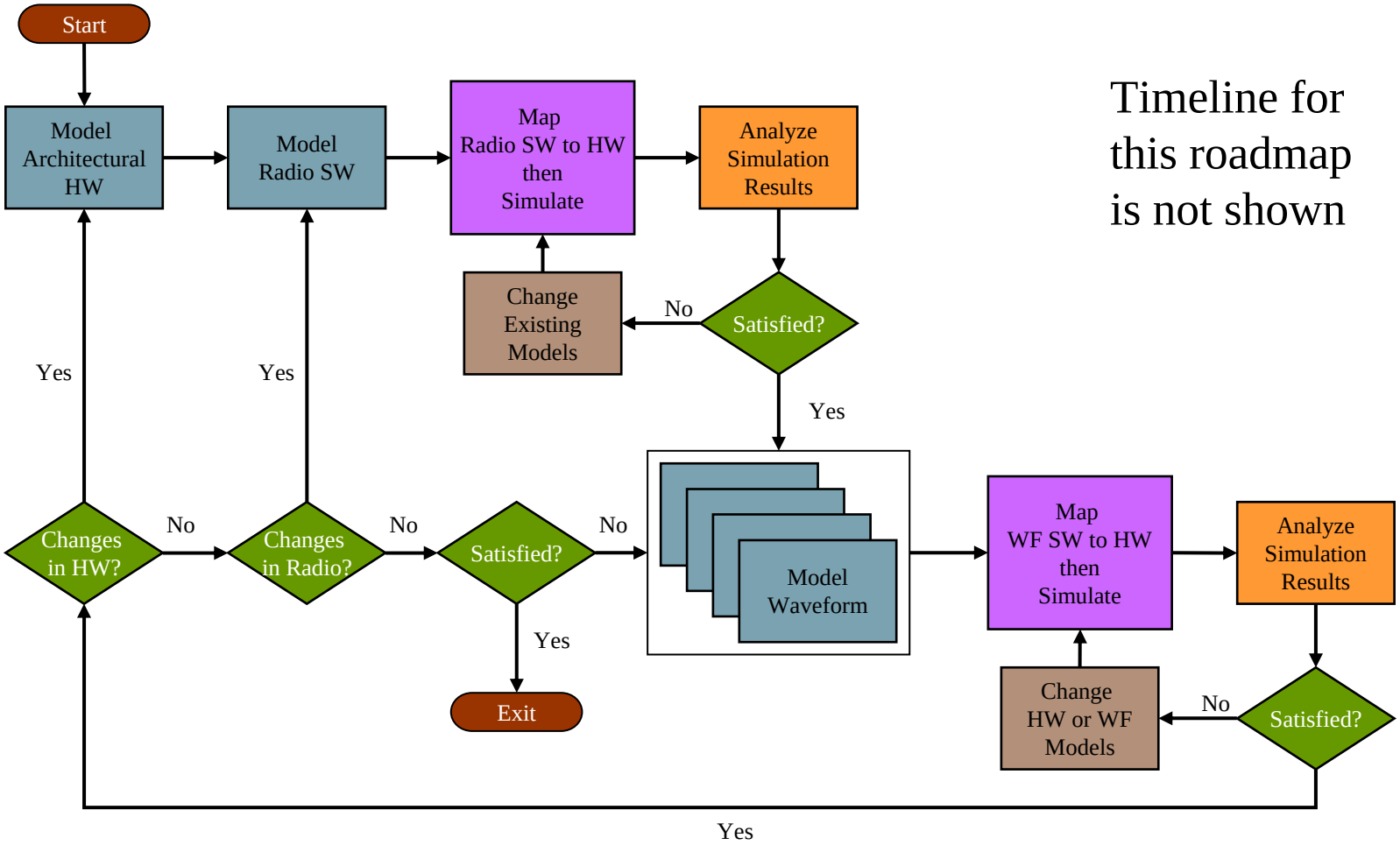
Defining Problem

- Hardware Capability Verification
  - Verify that the hardware resources meet the requirements for the radio software
- Software Portability Optimization
  - Validate that a particular waveform is properly partitioned to maximize software portability while satisfying application performance
- System Performance Analysis
  - Analyze end-to-end latency, component throughput, data and control bottlenecks to meet resource loading and/or critical timing requirements

Input Source Collection and Analysis

- Source Collection
  - Specifications
    - SCA and its Supplements, RTOS and CORBA
    - Waveform and radio application
    - JTR architecture
  - Data
    - Estimated and measured data
- Source Analysis
  - Identify controllable and uncontrollable inputs
  - Identify constraints on the decision variables
  - Define system performance measure

Developing Model: Roadmap



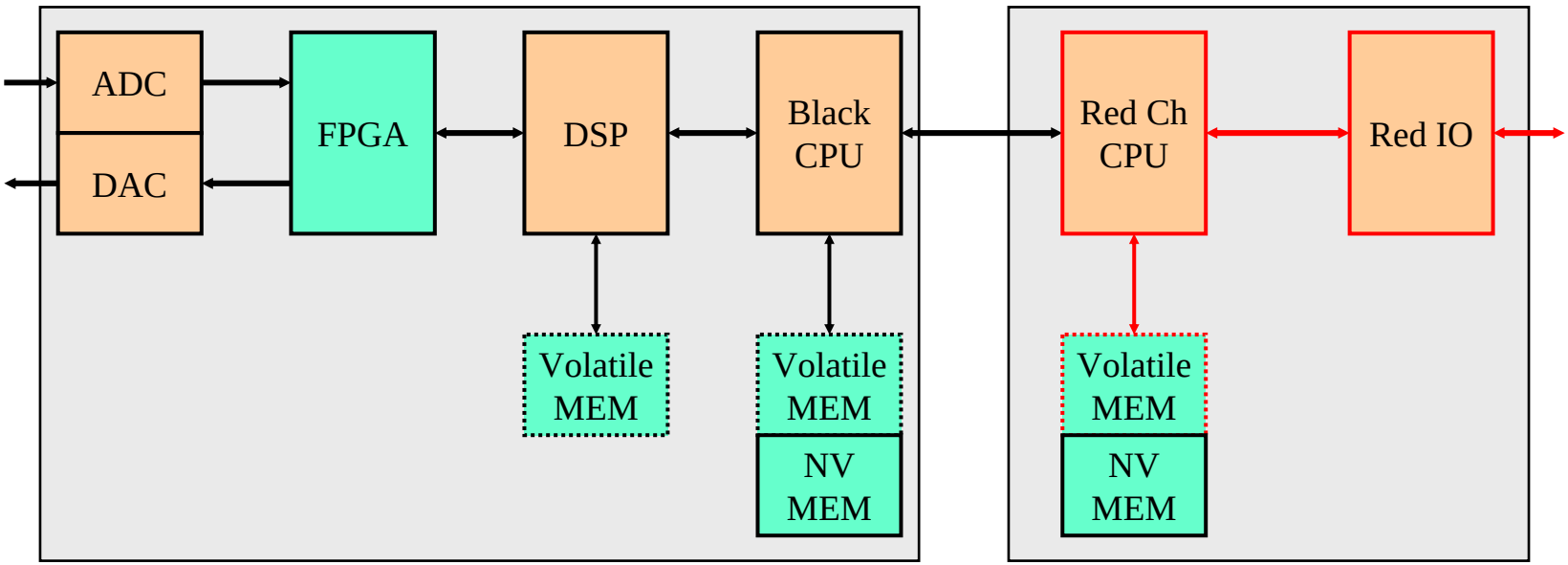
Timeline for this roadmap is not shown

BOEING®

Developing Model: Hardware Resources

- The architectural model describes the hardware resources used in processing or transporting the radio and waveform application data
  - Create Models of Resource Building Blocks
  - Build Models of HW Components
  - Generate Models of HW Architecture
- Resource name and its capacity are simulation parameters for a HW component

Hardware Architecture



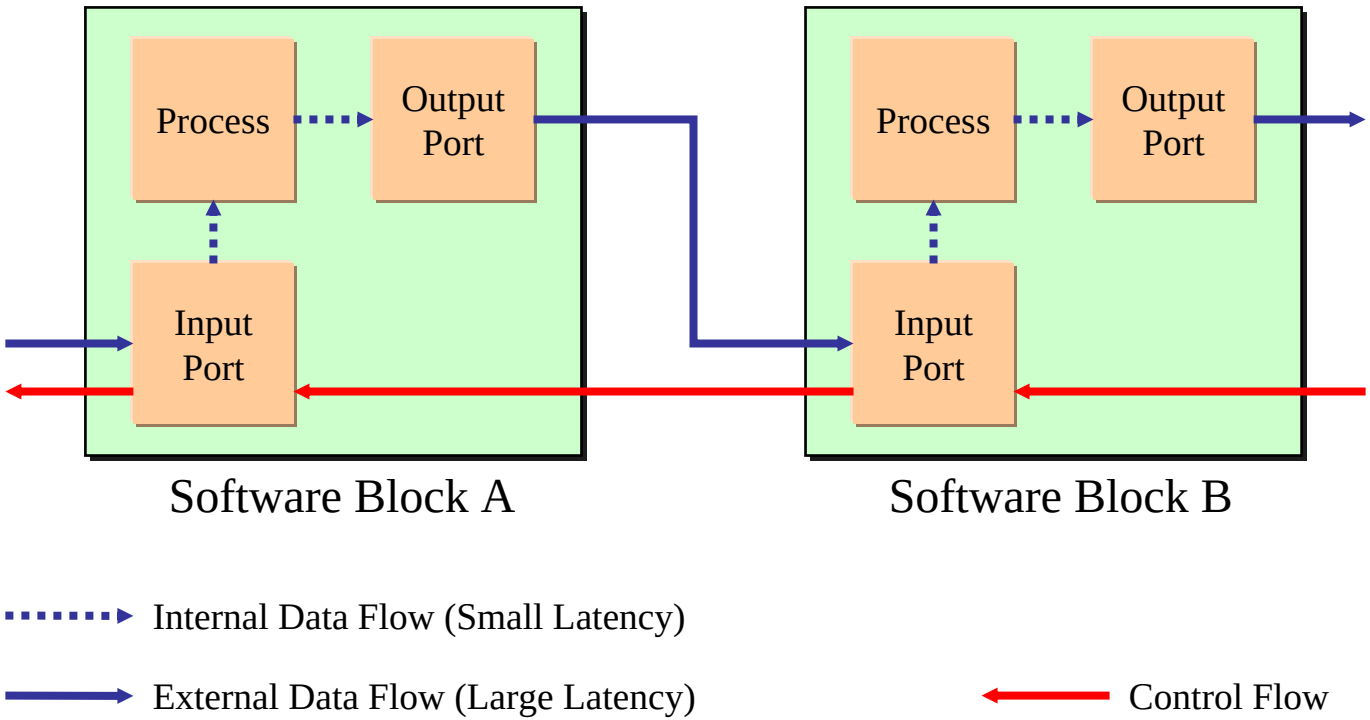
..... CORBA ORB Inside

Basic Resource

Process Resource

BOEING®

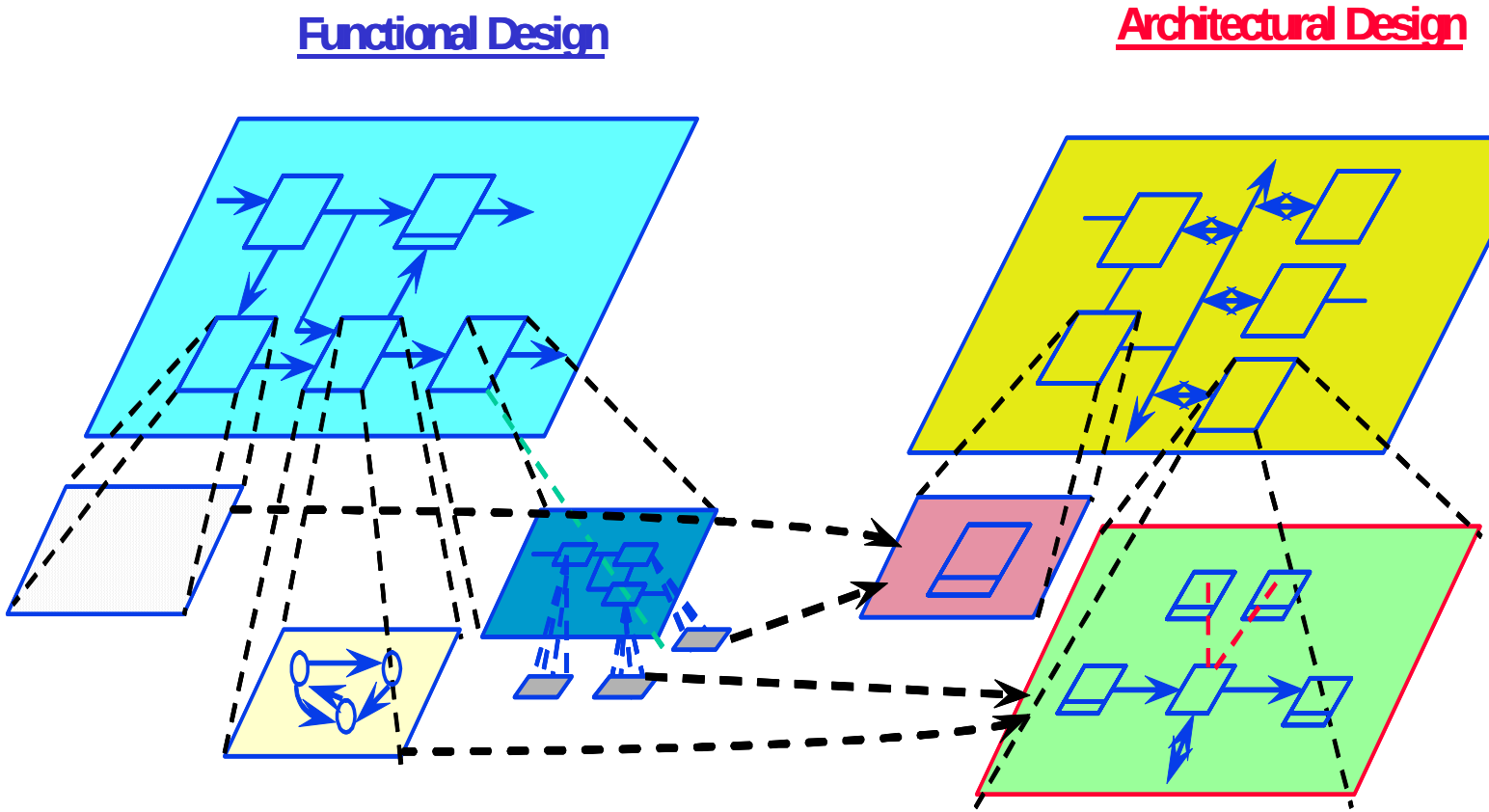
SCA Generic Building Block



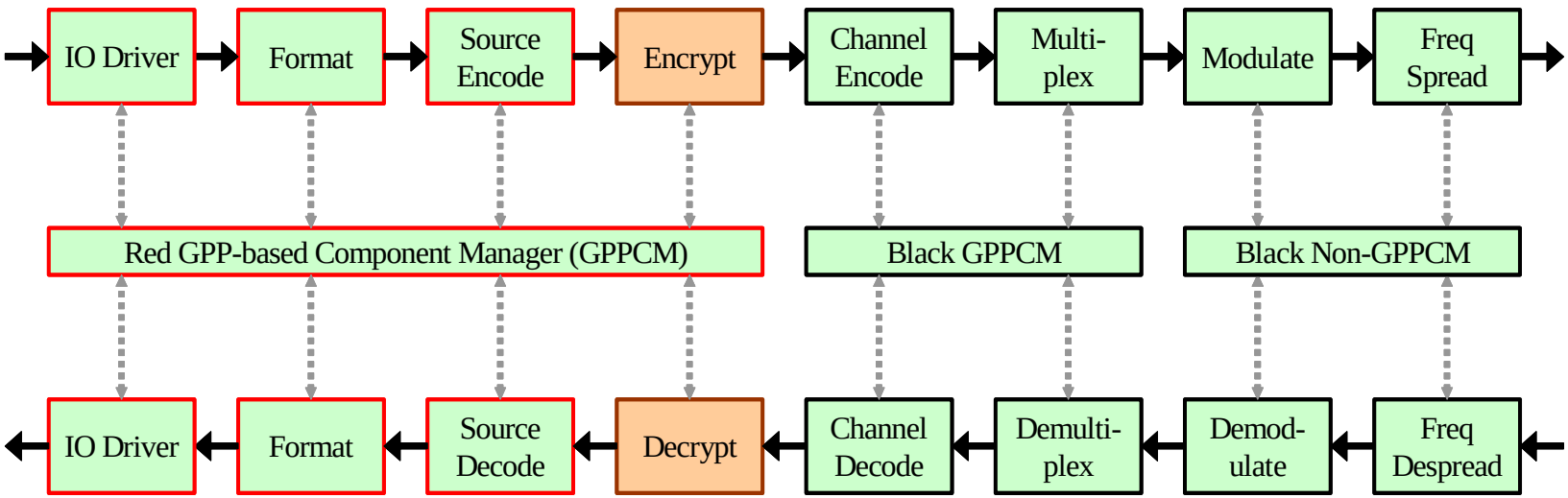
Tool Selection

- Co-Design tools provide two orthogonal views of a system
  - Architectural and functional views - which are linked by a partitioning specification
  - The capability for simulation of virtual system prototype
- A Co-Design tool by Foresight Systems

Software to Hardware Mapping



A Generic Communication Model



Problem Studies

- Base Scenario
  - Configuration Preset for Radio Operation
- Scenario I
  - HW Capability Verification
- Scenario II
  - SW Portability Estimation

Base Scenario – Defining Configuration

- Data Input
  - Input data rate is 200 message per second
  - Payload is 1500 bits/message
- Radio Resources
  - Red GPP = 400 Million Instructions / second (MI/sec)
  - Black GPP = 400 MI/sec
  - DSP = 800 MI/sec
  - Local Port = 500 Megabits / second (Mbps)
  - Remote Port = 100 Mbps
- Waveform Utilization
  - Red Component = 0.375 MI 4 components
  - Black Component = 0.75 MI 2 components
  - DSP Component = 1.5 MI 2 components
  - Local Port = 0.0625 Mb 5 ports
  - Remote Port = 0.0625 Mb 3 ports

BOEING®

Base Scenario – End-to-End Latency

Processors + Local Ports + Remote Ports

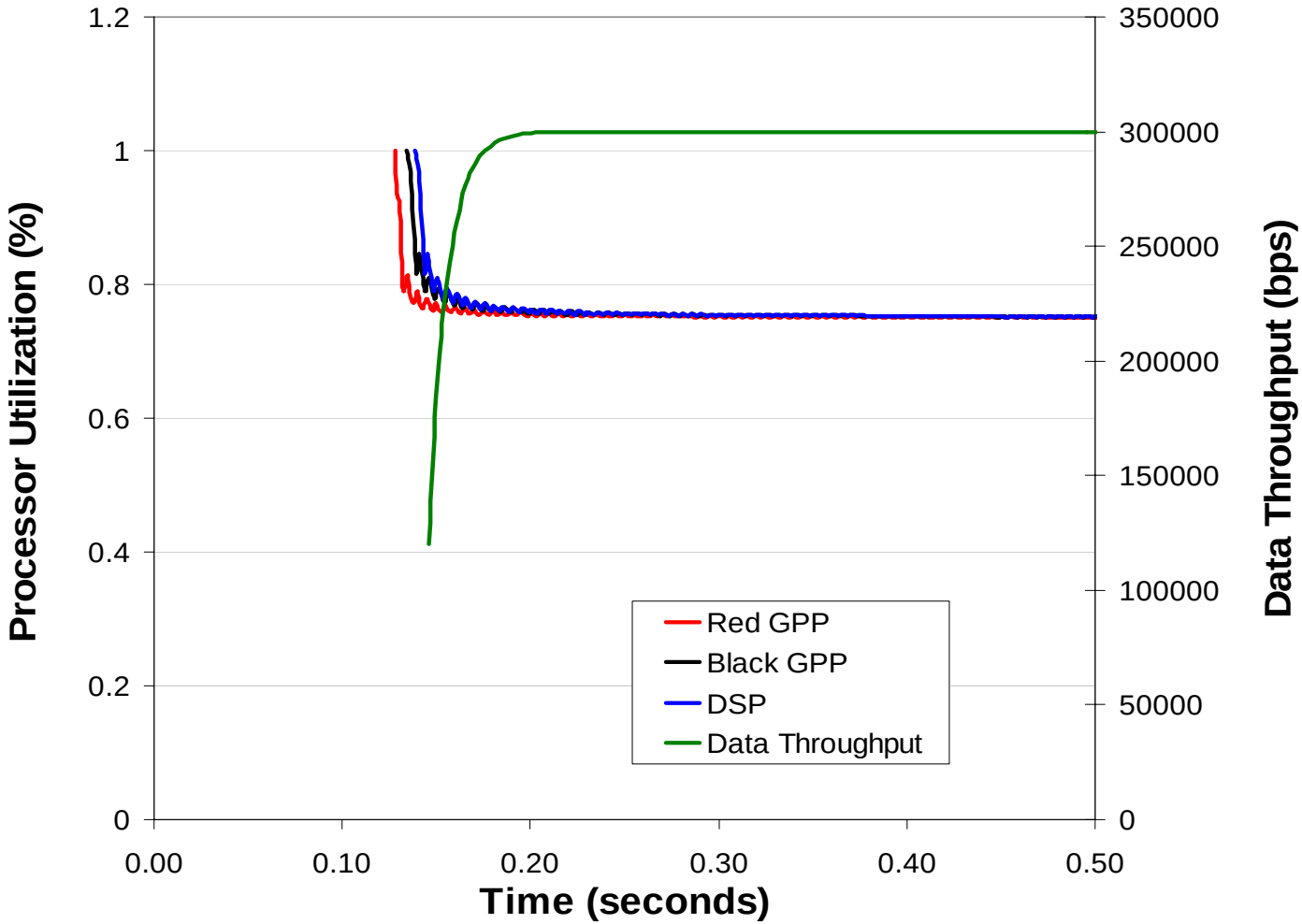
= (4*0.375/400 + 2*0.750/400 + 2*1.5/800)
+ (5*0.0625/500) + (3*0.0625/100)

= (0.00375 + 0.00375 + 0.00375)
+ 0.000625 + 0.001875

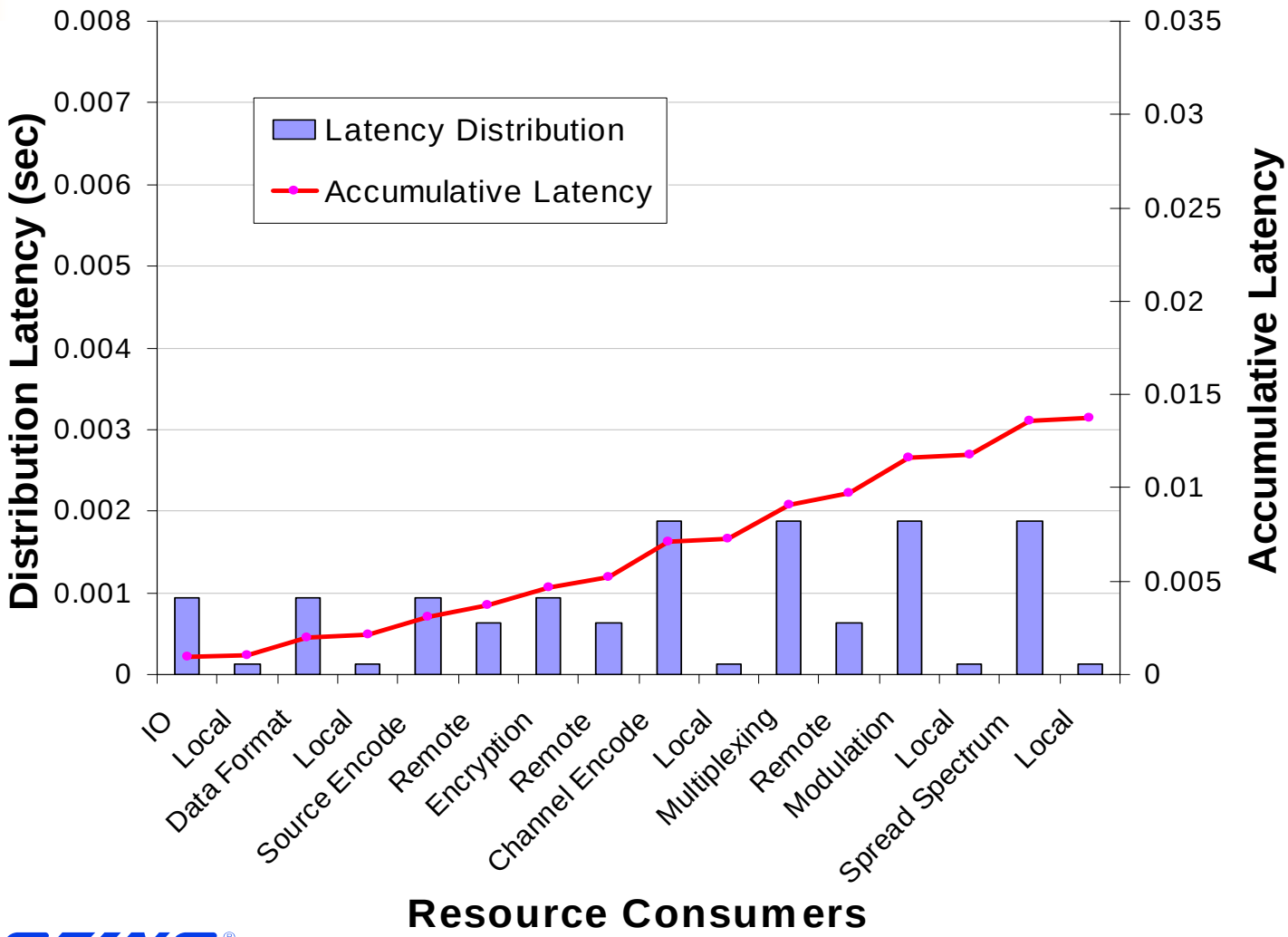
= 0.01375 sec

BOEING®

Base Scenario – Resource Utilization



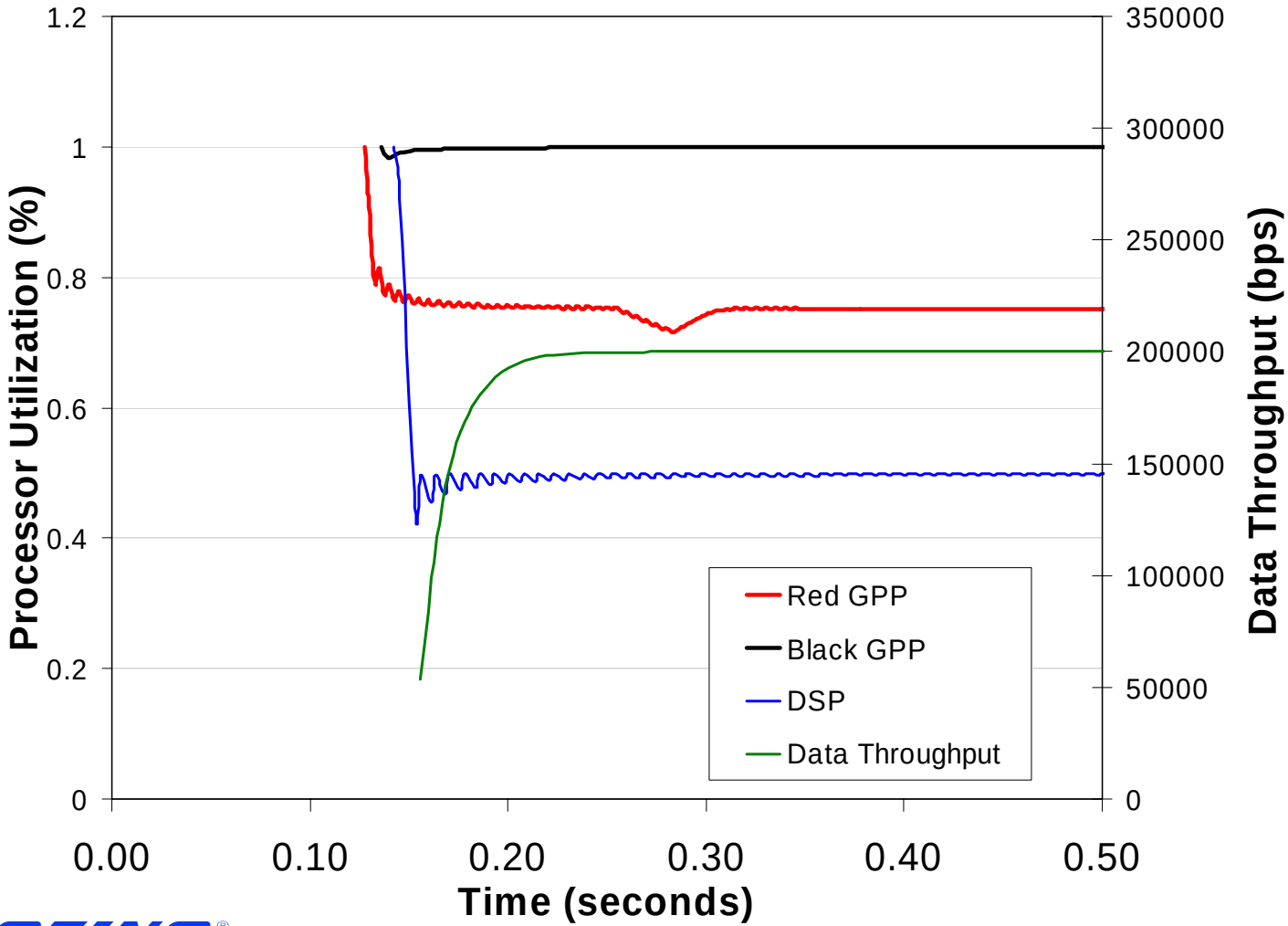
Base Scenario – Latency



Scenario I

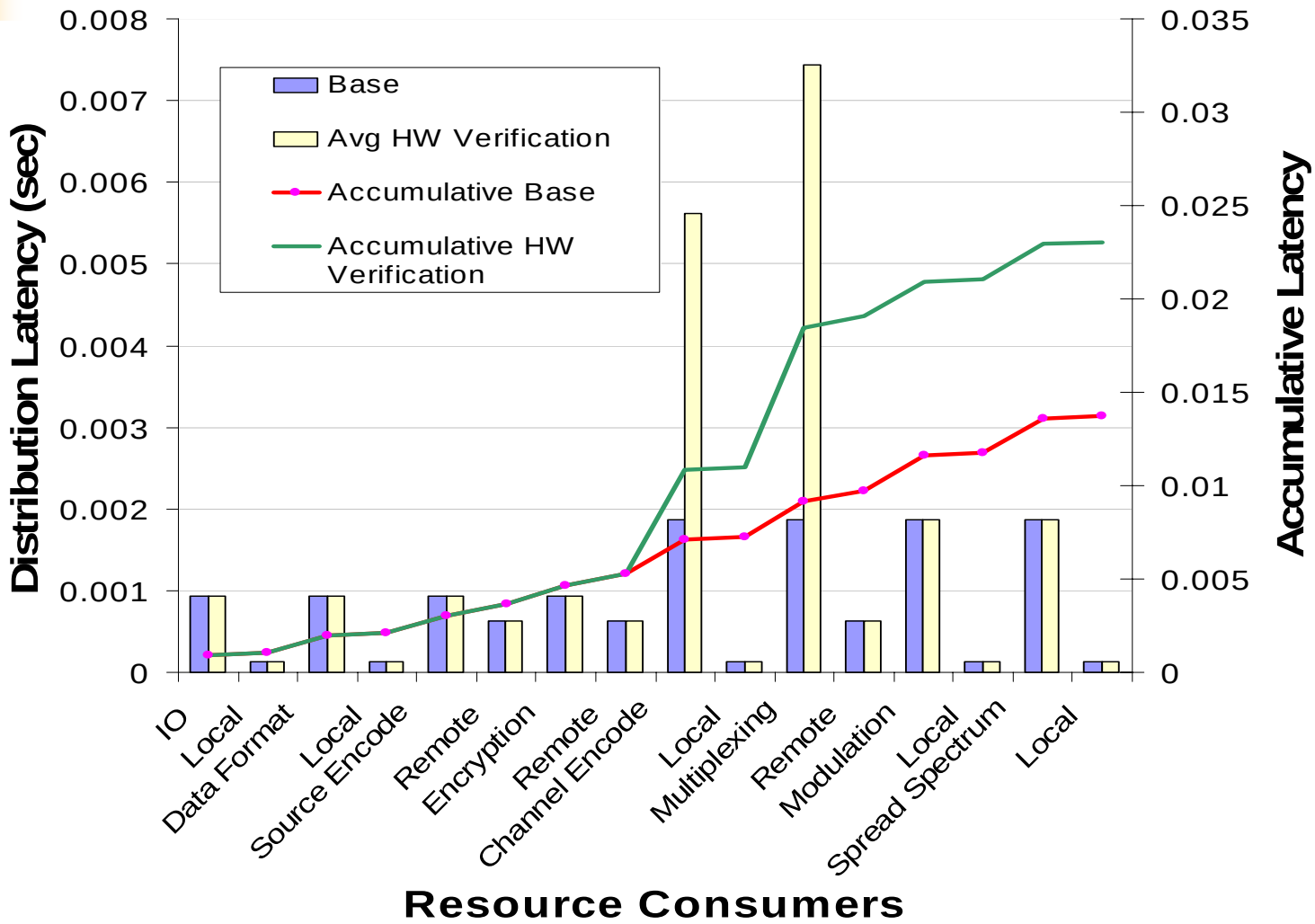
HW Capability Verification

Scenario I – Resource Utilization



BOEING®

Scenario I – Latency



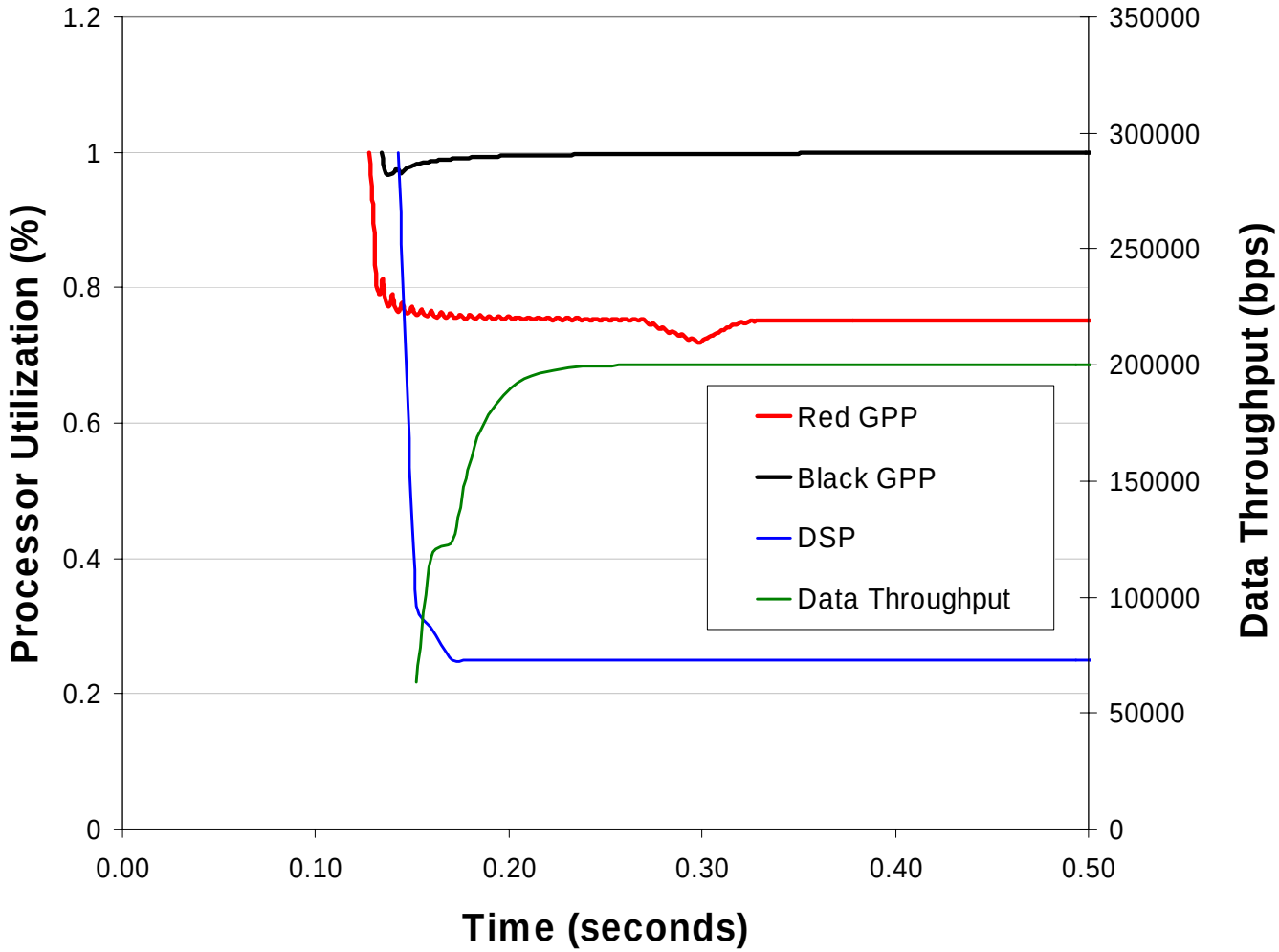
Scenario I – HW Verification Summary

- Configuration
  - Reduce Black GPP from 400 to 200 MIPS
- Results
  - Black GPP utilization increased to 100%
  - Data throughput reduced by 33%
  - Latency increased by 68%

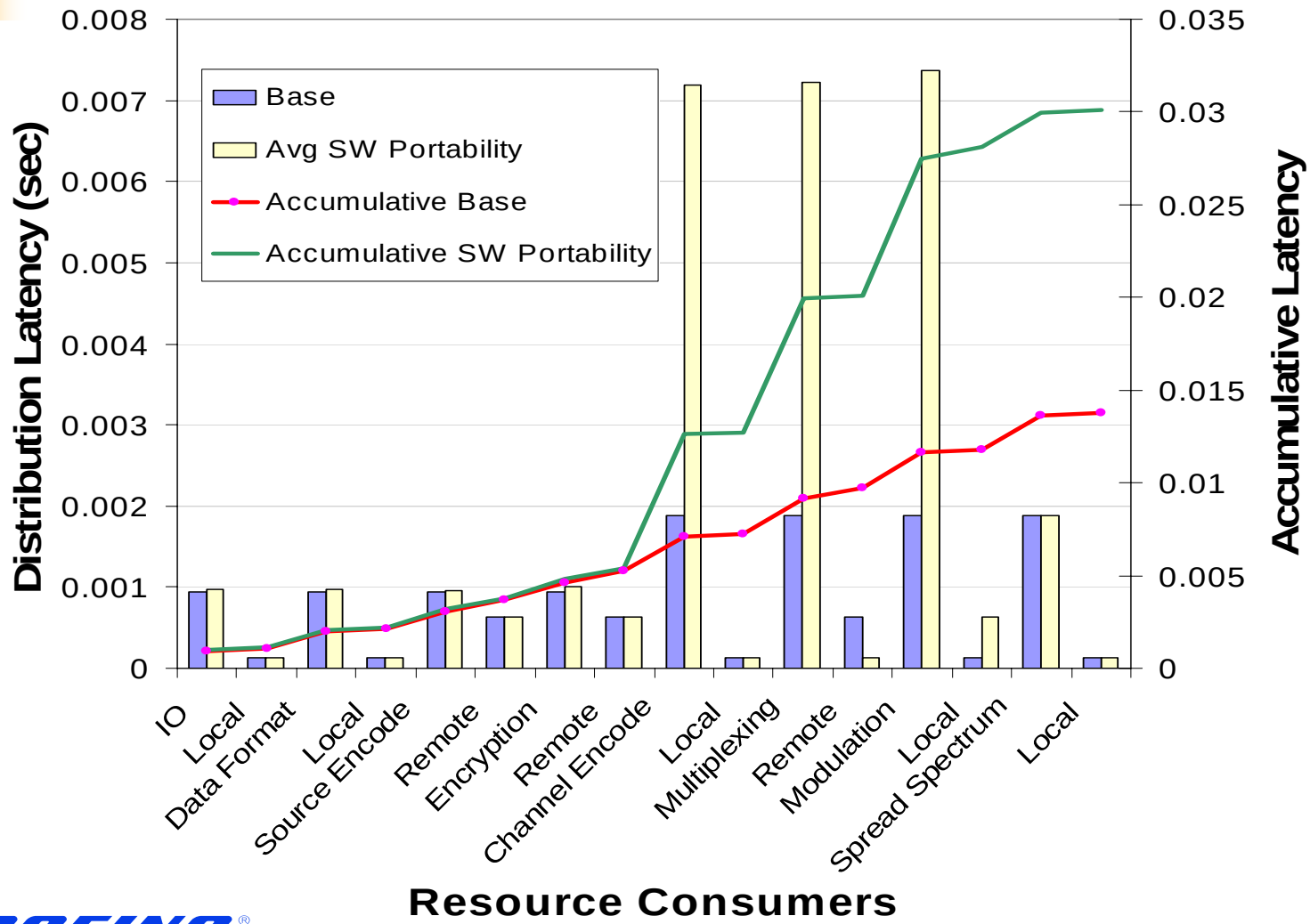
Scenario II

SW Portability Optimization

Scenario II – Resource Utilization



Scenario II – Latency



Scenario II – SW Portability Summary

- Configuration
  - Re-map the modem software component from DSP resource to Black GPP resource
- Result
  - Black GPP utilization increased to 100%
  - Data throughput reduced by 33%
  - Latency increased by 119%

Conclusion

- Verified that hardware capability satisfied resources required by radio software
- Validated that a waveform partitioned to match hardware resources, and maximized software portability and performance
- Co-design approach helps to optimize flexibility and performance
- It minimizes risks and maximizes chance of successful completion

Future Work

- Trade studies on
  - Message priority and length
  - Data throughput and latency
  - Component queue length
  - Incoming traffic distribution
  - Time/space partitioning
  - Different hardware architectures
- Upgrade models with SCA 3.x