Advanced Research Briefing

Presented to the joint meeting of the Real-Time & Embedded Program Group and the Quality of Service Task Force
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Advanced Research Vision

- Technical Challenge:
  - Allow **reliable** processing of critical, high-value, time-urgent data in networked systems using commercial off-the-shelf components
- Business Vision:
  - Participate in software research and advanced development which will enhance customer's ability to provide highly-available, high-capacity IT services
  - Serve as a consulting and technology transfer resource to allow commercial and government customers to use DARPA- and Government-sponsored technologies

QUITE

- Integration of 40+ QoS research projects sponsored under DARPA Quorum program
- Quorum program goal: develop innovative software-based approaches to end-to-end QoS
- QUITE provides testbed, characterizes and combines promising research results, transfers technology to government and commercial markets

Architectural Patterns Explored within Quorum (i)

- Adaptive Application
  - An application that can operate using differing algorithms and/or strategies based on the sets of resources that are available.
  - QuO, Quasar, HPF, Linux/RK, RT-ARM
- Application Path
  - An execution sequence that requires a particular set of resources to execute successfully. (A POSIX thread is a special case of this abstraction for CPU usage.)
  - DeSiDeRaTa, Sesco, CORDS/GIPC

Architectural Patterns Explored in Quorum (ii)

- Resource Management Components
  - The extraction of resource usage strategy from individual applications into a separate component in support of a more comprehensive strategy in utilizing available resources.
  - DeSiDeRaTa, Sesco, Globus
- Fault Management
  - The extraction of information about failures and failure dependencies into a separate component in support of a more comprehensive strategy in handling failures and in predicting future failures.
  - FFD

Architectural Patterns Explored in Quorum (iii)

- QoS Property Factoring
  - The structuring of applications based on the QoS requirements of individual subcomponents.
  - AQuA, HPF, Quasar, Darwin, Linux/RK
- Scalable Fault Tolerance
  - The parallelization of application algorithms in support of scalability and fault tolerance.
  - Resource Management, Group Comms

Design Patterns Explored within Quorum (i)

- Layered Resource Management
  - The separation of resource management into multiple components within a hierarchy in support of scalable systems.
  - RT-ARM, Sesco (w/ enhancements),DeSiDeRaTa, Globus
- Group Communications
  - A method for reliably communicating multicast messages in support of scalability and fault tolerance.
  - Ensemble, CORDS/GIPC, Cactus, Armada

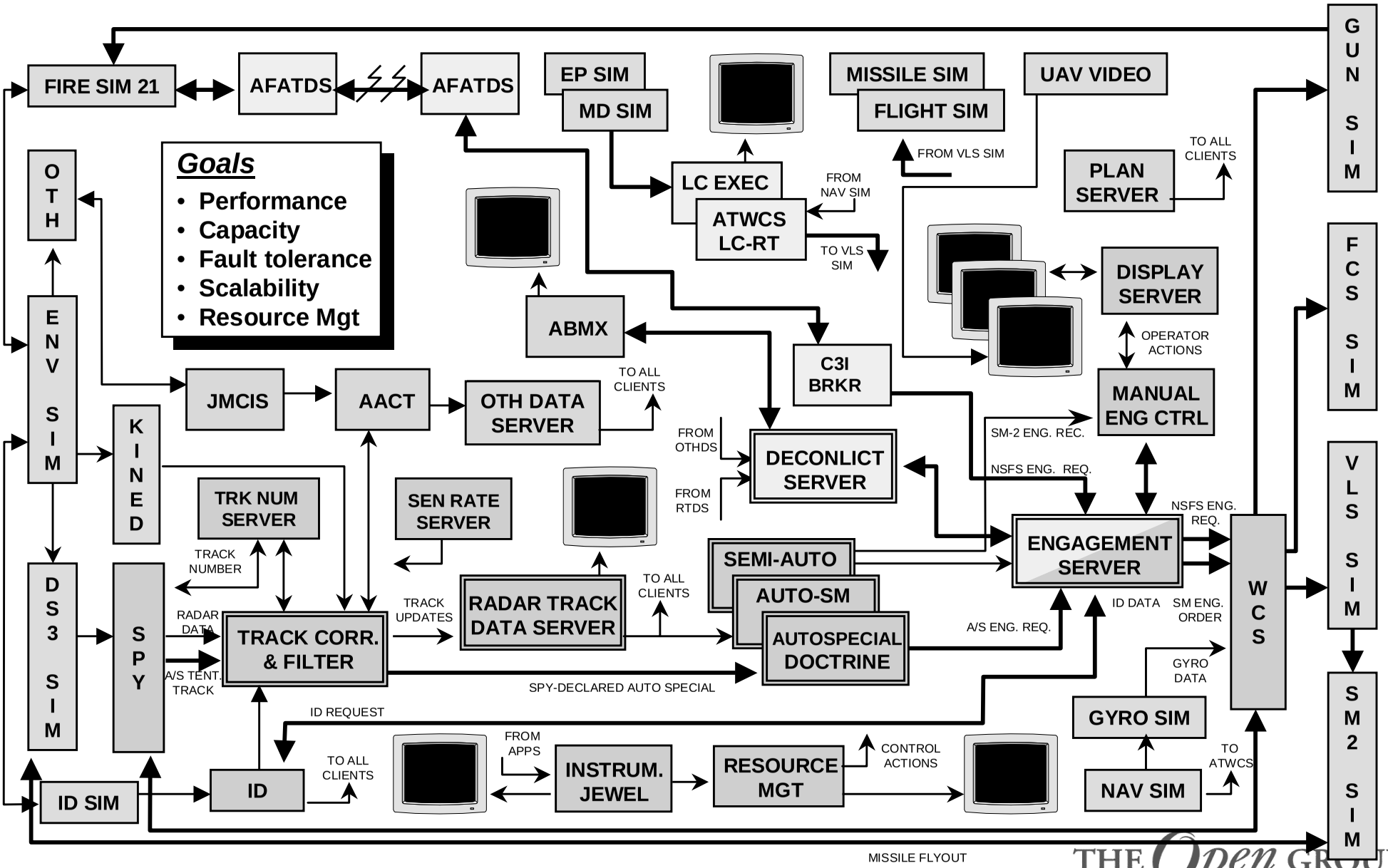
Design Patterns Explored within Quorum (ii)

- Integrated Instrumentation
  - Use of dynamically execution status for the purpose of adaptively assigning resources towards the most effective use.
  - QMS, DeSiDeRaTa, Remos
- Real-Time Middleware
  - Middleware that propagates guarantees on QoS properties from lower levels, such as OS and hardware.
  - TAO, CORDS/GIPC, Java/RK

HiPer-D: An Example Context

- High-Performance Distributed (HiPer-D) Project (at NSWC in Dahlgen, VA) is applying COTS-based, distributed computing techniques to prototype shipboard weapons systems
- Objective is capacity scalability (Load Invariant Computing)
- AAW (ship self-defense) is “hard” real-time
  - Mandated timing requirements
  - Mandated failure recovery requirements
  - “Auto-Special Doctrine” execution path
- Supporting COTS technologies
  - COTS hardware and networks
  - Significant use of COTS software
    - Supplemented with purpose-built software
  - Group communications

HiPER-D FUNCTIONAL BLOCK DIAGRAM (DEMO 99)



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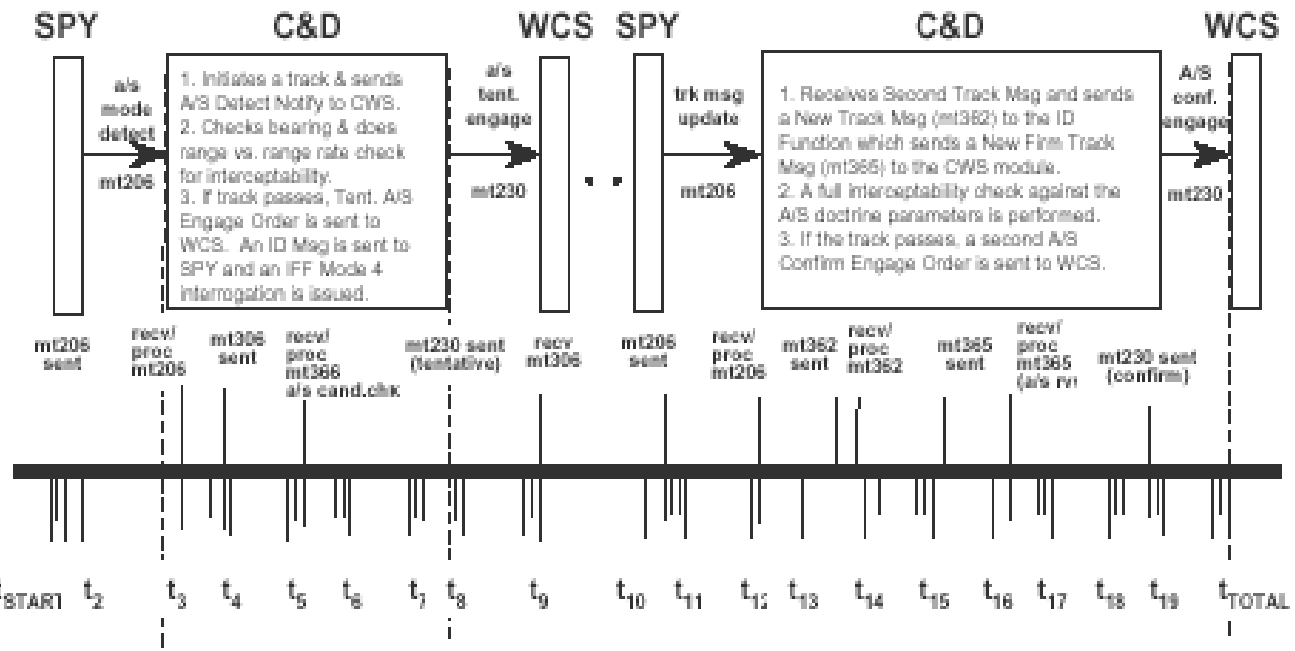
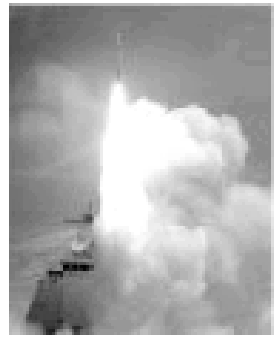
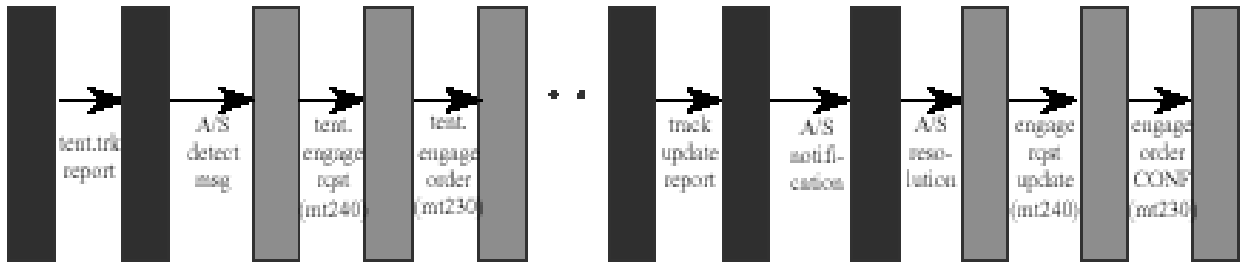
Why DD-21 Needs Assured Response: SPY Radar Auto-Special Time-Line





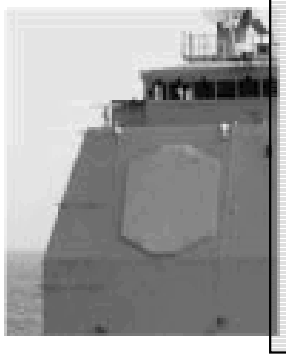


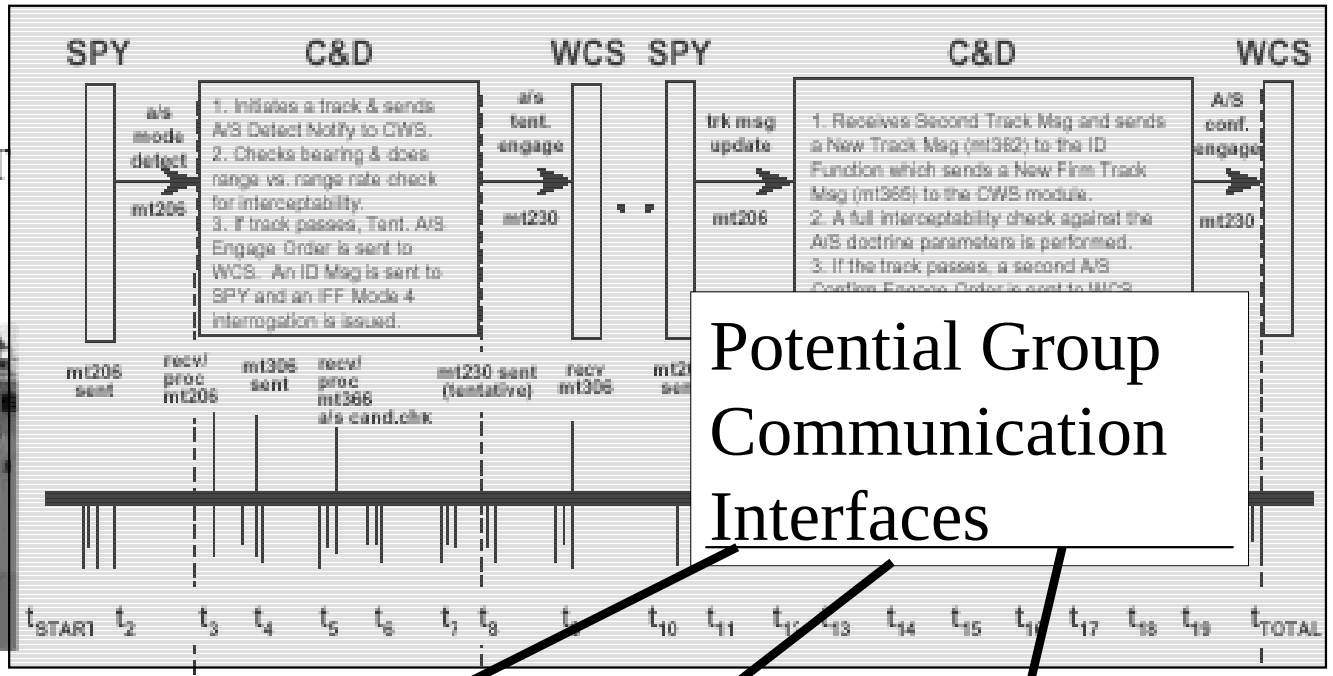
Group Communications

- Reliable multicast technique based on atomic multicast—each message is reliably delivered to either (exclusive or)
  - —all designated recipients
  - —no recipients
- Popularized by Ken Birman at Cornell U.
  - Initial research/product was Isis
  - Current implementation is Ensemble

Why DD-21 Needs Assured Response: SPY Radar Auto-Special Time-Line

CURRENT AWS





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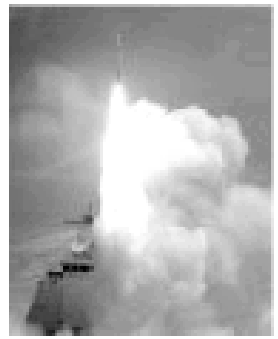
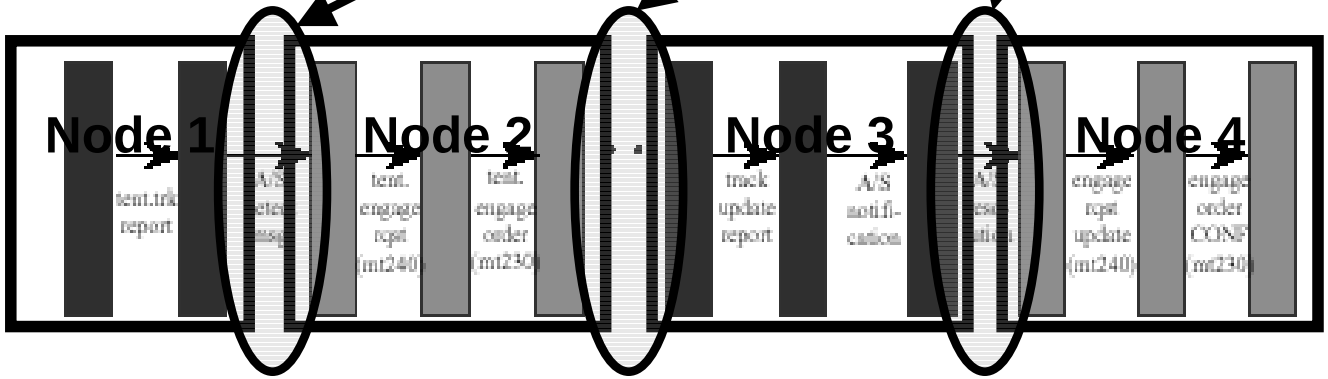


Potential Group Communication Interfaces

AdCon-21



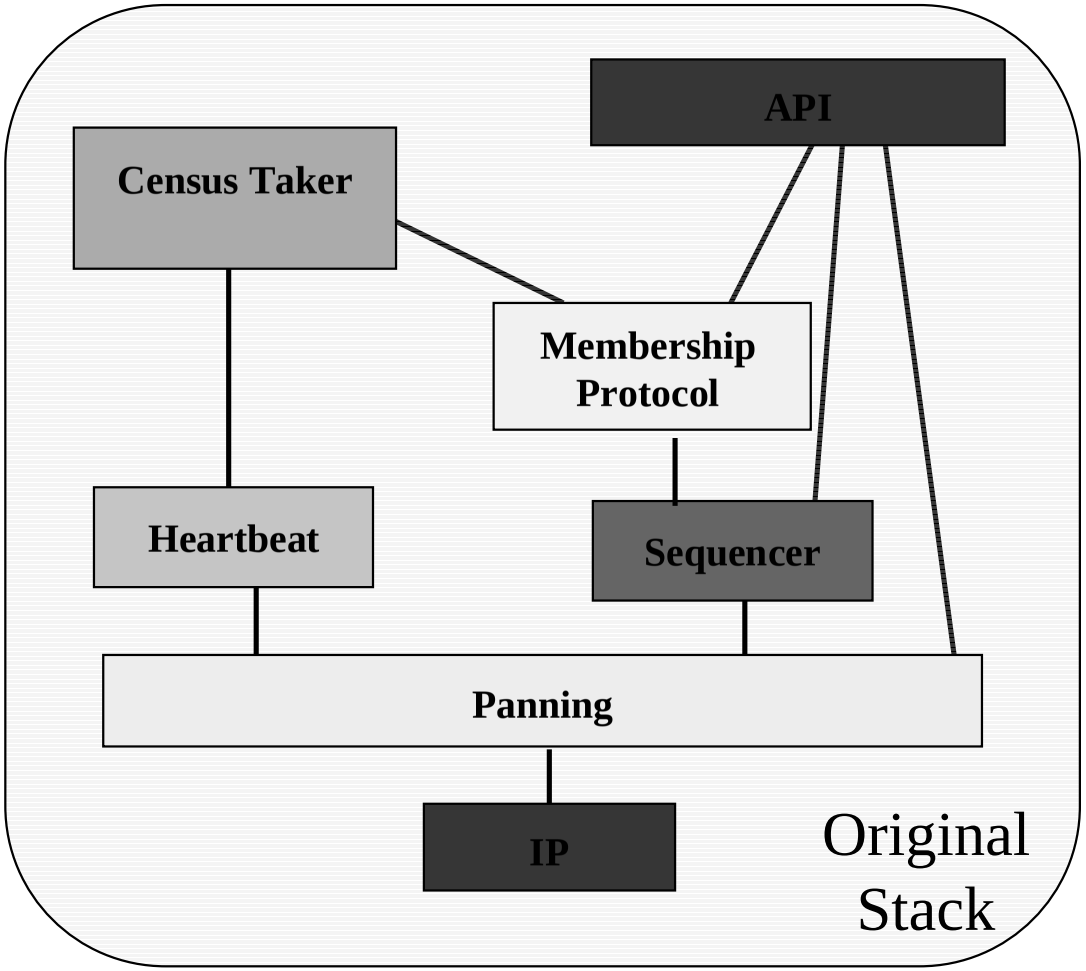
CORDS and GIPC

- CORDS: A framework for constructing high-performance, real-time communication protocols
- GIPC: A protocol (built using CORDS) which offers real-time group communication services
  - All members of group are guaranteed to receive messages in identical order
  - Rapid recovery from failure of group member
- Group-ordered communications + Layered Resource Management = Scalable, Fault-tolerant systems

Fast Failure Detector (FFD)

- General Goal of FFD:
  - Provide faster, more reliable detection of host node failure than other components on COTS systems
- Specific Goal of FFD Integration Effort in HiPer-D test-bed:
  - Detect and report host failure within 250 msec
  - Insert failure notification into (non-real-time capable) Ensemble
  - This will allow an application to recover from host failure within 1 second worst case, even with substantial state reacquisition
  - (FFD currently operational in HiPer-D test-bed with observed notification times of 90-160 msec on Solaris and Linux)
- Method:
  - Isolate detection mechanism into separate component and provision it with higher priority and/or reserved resources
  - Insert failure notification into original component

Group Membership Protocol Stack



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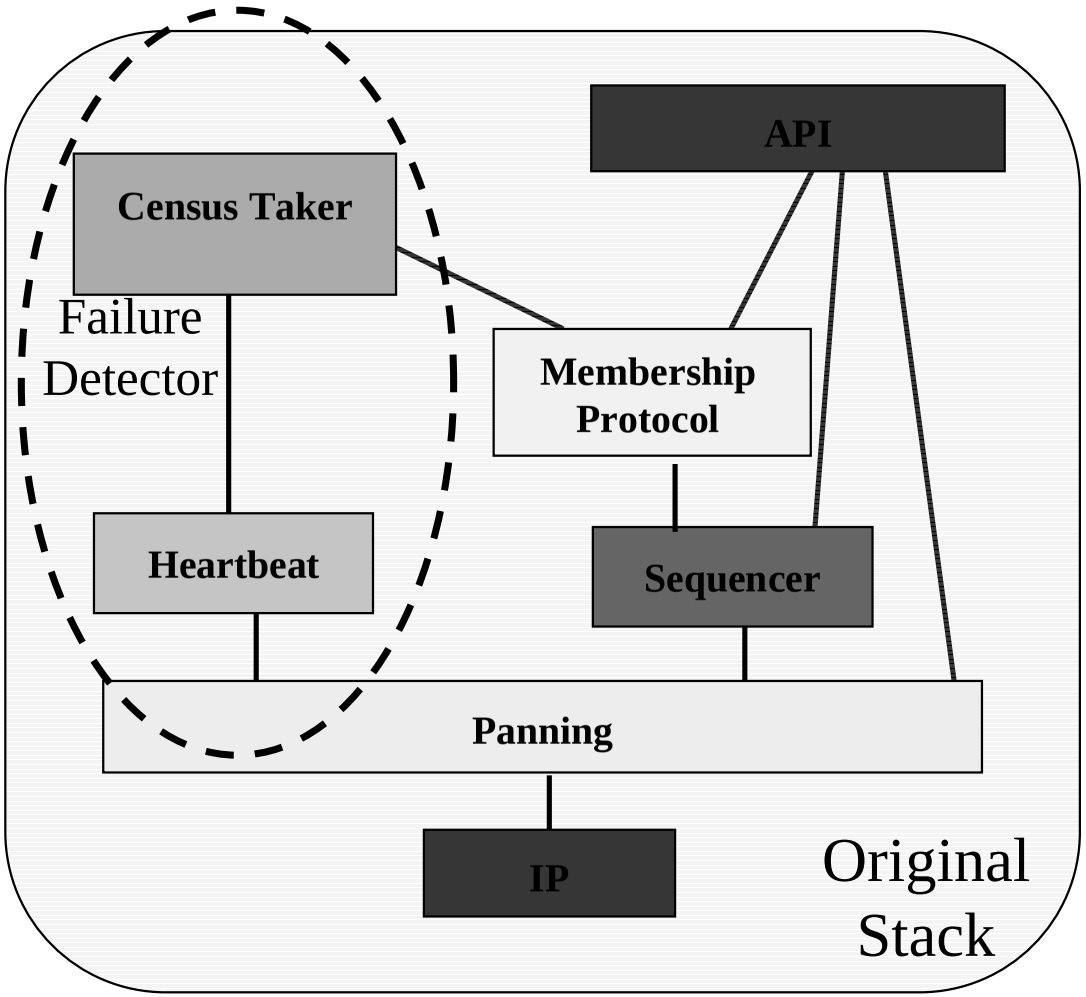

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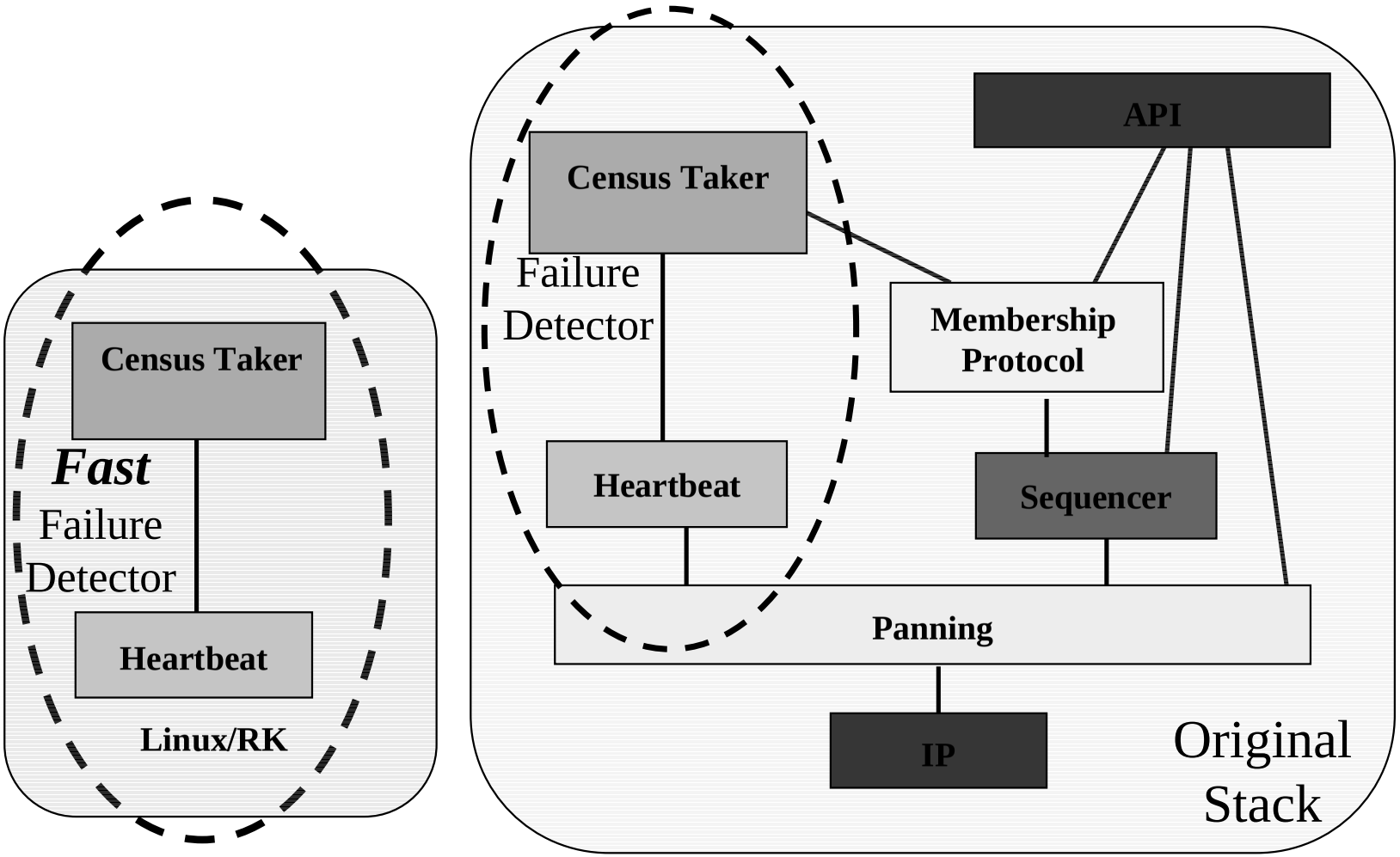

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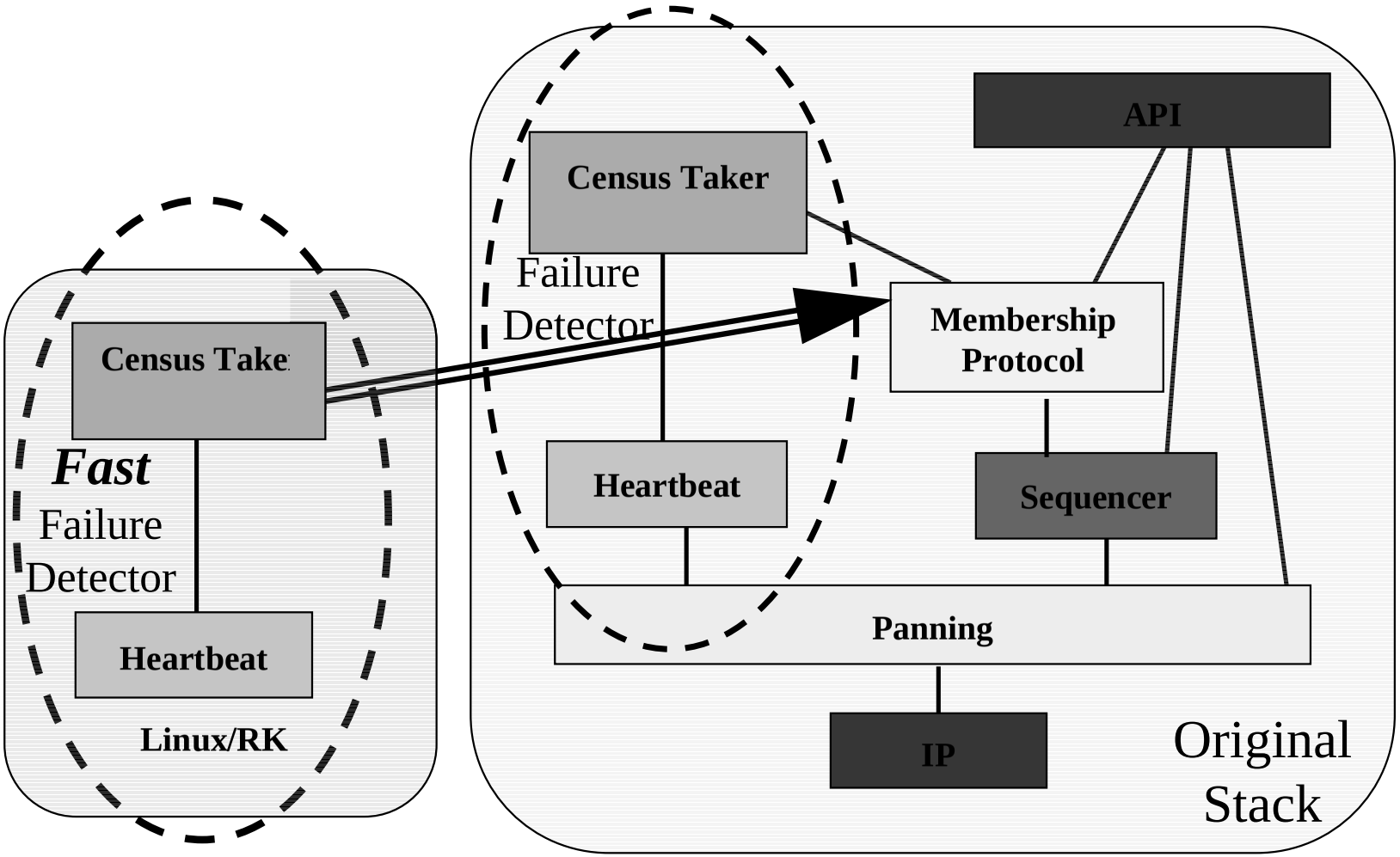

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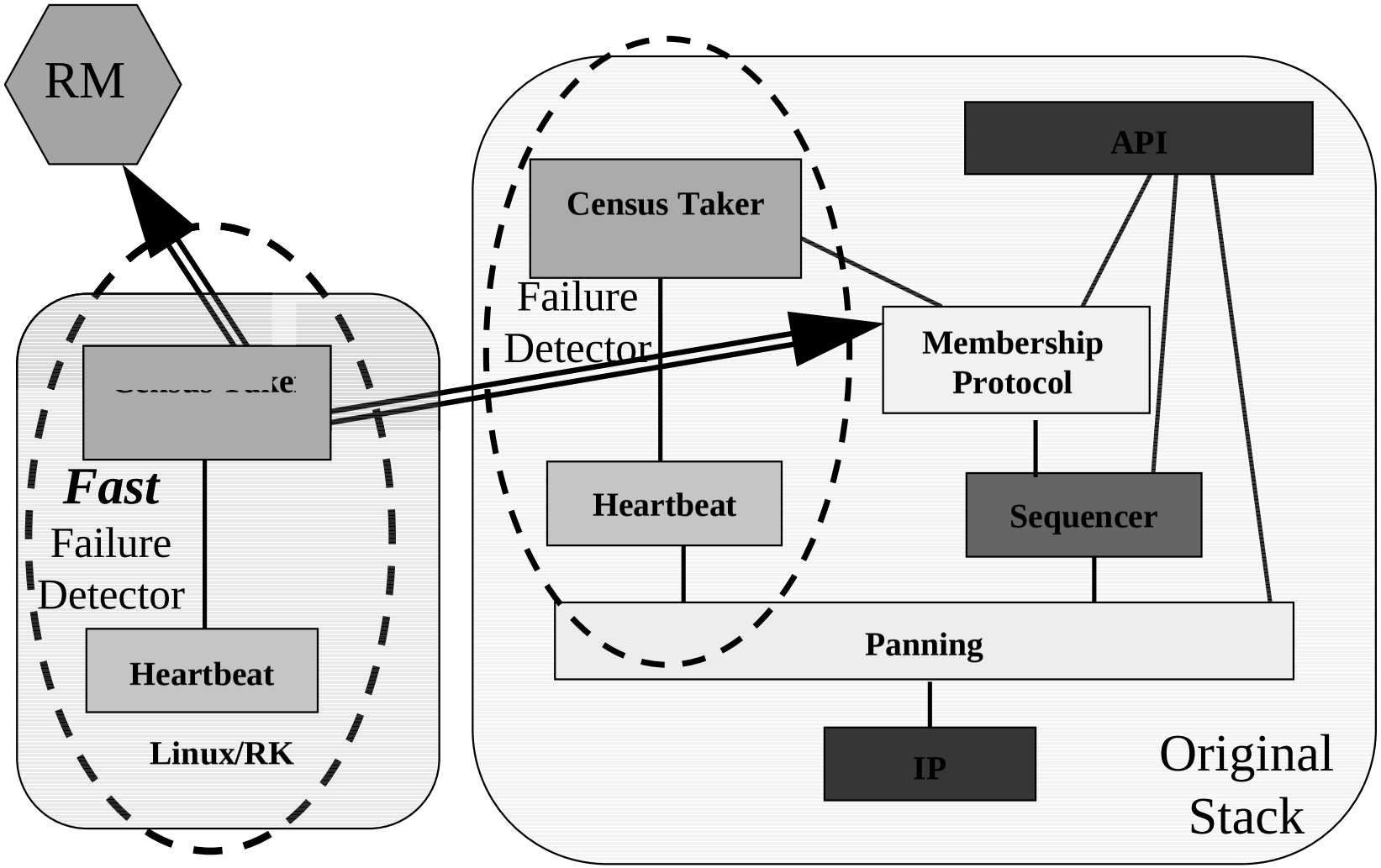
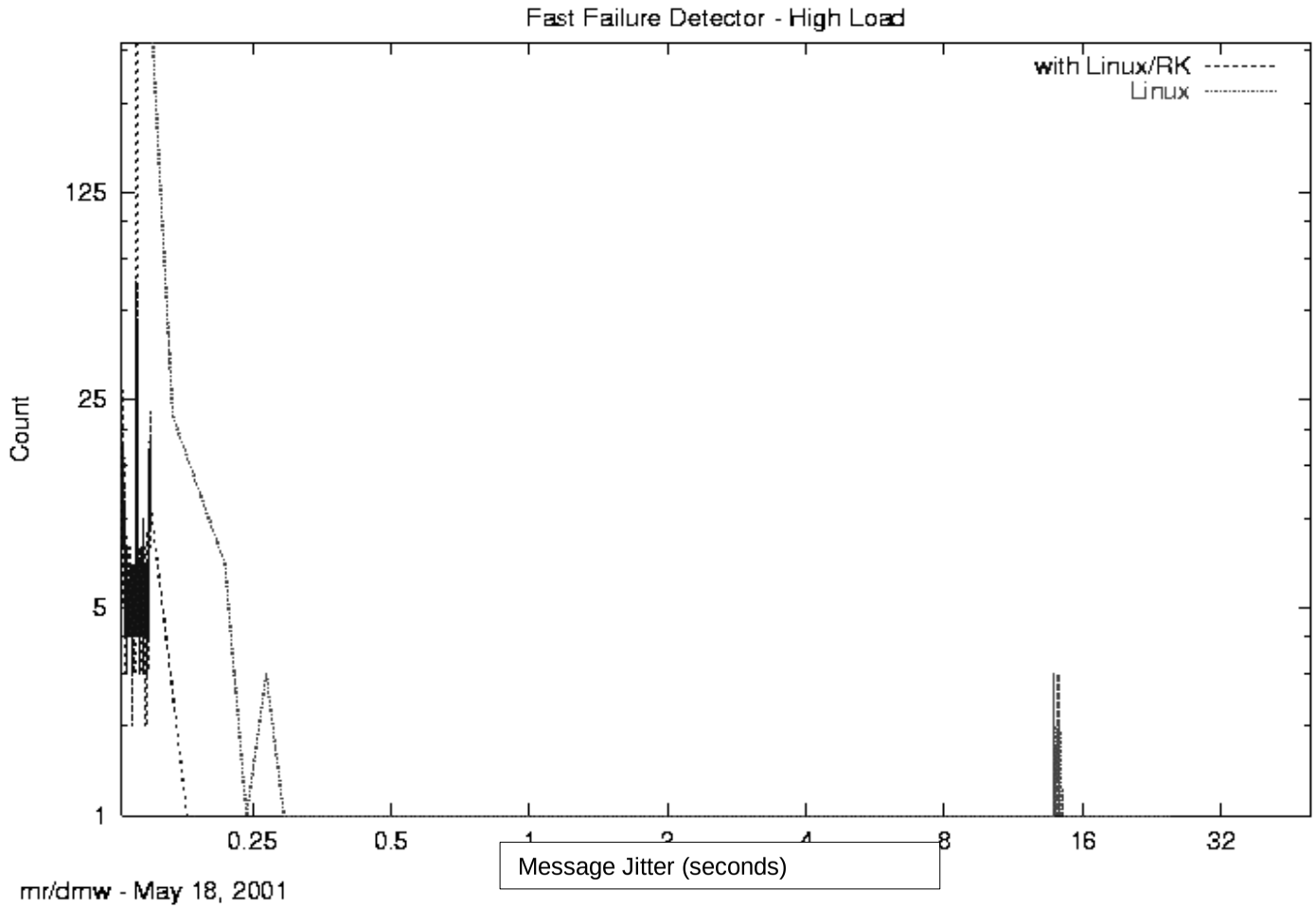
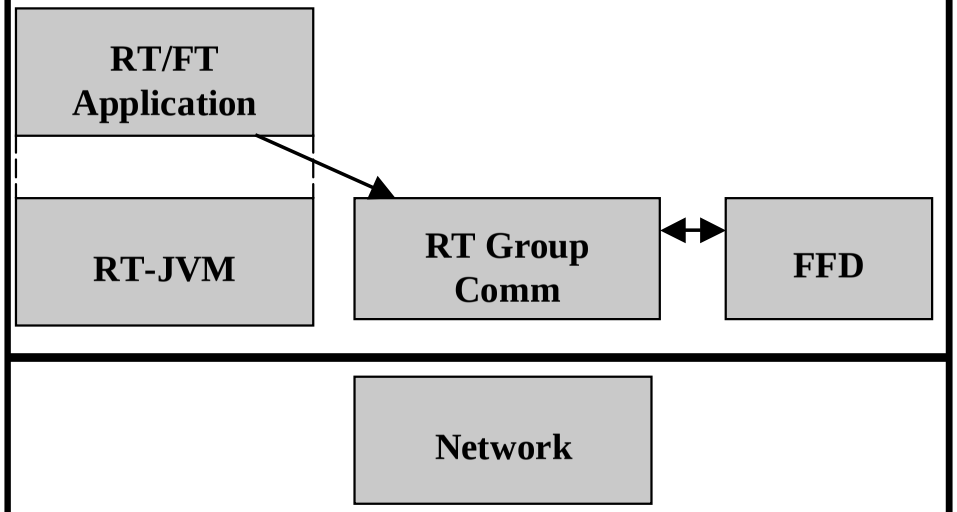


FFD Message Latency (Jitter) Characterization



SBIR: Open Tool-Kit for Mission Critical Systems

CONCEPT DESCRIPTION



ISSUE REQUIREMENTS/NEEDS: (Quantified):

- Must reduce lifecycle costs of building and maintaining computer-based shipboard weapons systems
- Must increase capabilities by leveraging advances in commercial market to address requirements of real-time, fault-tolerant tactical systems.
- Must assure supportability and ability to meet evolving Navy mission goals by reducing system complexity.

BENEFITS (Quantified):

- Reduces deployment costs via reuse of software
- Speeds development by increased programmer productivity
- Reduces maintenance costs due to less-complex designs
- Leverages commercial software advances while protecting installed base

CAPABILITY REQUIRED	CRITICAL TECHNOLOGY	RISK ASSESSMENT	EXIT CRITERIA
Reusable real-time, fault-tolerant software components Ability to leverage COTS software for use in real-time, fault-tolerance applications	Standards-based framework/tool-kit specialized for real-time, mission-critical systems Real-time Java™ Real-time group communications Use of evolving standards, e.g., CORBA, UNIX	•RT CORDS/GIPC capability demonstrated •RT/FT standards applicability demonstrated •Integration of COTS and non-COTS components within framework	Use of prototype 1 in Navy ATD test-bed Review by weapons system engineering team of Navy prime contractor Use of prototype 2 in Navy ATD test-bed

NOTE: Indicate the High, Medium, and Low Risk Levels for the above with Red, Yellow, and Green Background, respectively.

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Commercialization Plan

- Multiple, concurrent technology insertion paths
  - Productization (3-5 years)
    - Transfer of resulting technology to traditional vendors
    - Availability to multiple suppliers
  - Standardization (2-5 years)
    - Continuing adaptation towards emerging standards
    - Early influence on standards development
  - Direct insertion via trial use (ongoing)
    - Continued HiPer-D participation
    - Proposed collaboration with Navy prime contractors
- Framework: interoperability and compatibility
  - Additional components from other vendors can be incorporated into this framework
  - Interoperable with existing, deployed systems and components

Status and Next Steps

- SBIR Status
  - Invitation to Phase II from NSWC
  - Plan submission 1 Feb
  - Seeking commercialization and tech transfer partners
- Follow-on work
  - Versatile Fault-Tolerance Component SBIR
  - Peer-Peer Resource Discovery & Management SBIR
  - Weapons Open Management Architecture SBIR

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