SERVICE AVAILABILITY™ FORUM

Open Specifications for Service Availability

Introduction to the Service Availability Forum

Contents

- ***Introduction***
- ***Quick AIS Specification overview***
- ***AIS Dependability services***
- ***AIS Communication services***
- ***Programming model***
- ***DEMO***

Design of dependable services

- ***Two parts of functionality***
  - Business logic
    - Implements the service
  - Common functionality
    - Communication, management, fault tolerance…
    - **This is where SA Forum AIS comes into picture**

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Construction of a service

- ***Define the functionality***
- ***Plan the architecture***
  - Components, roles
- ***Integrate fault management***
  - Service state monitoring
  - Management
- ***Plan recovery***
- ***Communication between components***

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Construction of a service

- ***Define the functionality***
- ***Plan the architecture (AMF)***
  - Components, roles
- ***Integrate fault management (AMF)***
  - Service state monitoring
  - Management
- ***Plan recovery (CKPT)***
- ***Communication between components (MSG, EVT)***

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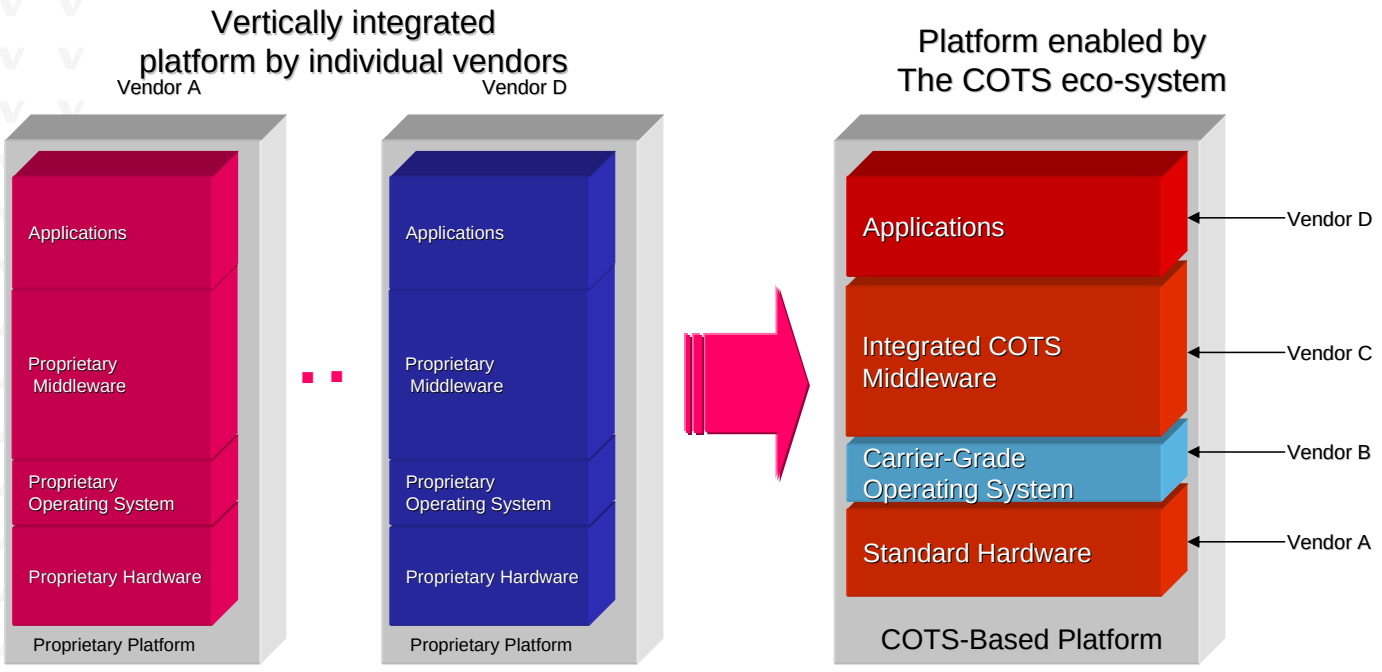
The Transition

COTS adoption is accelerating transition from vertical to horizontal industry model



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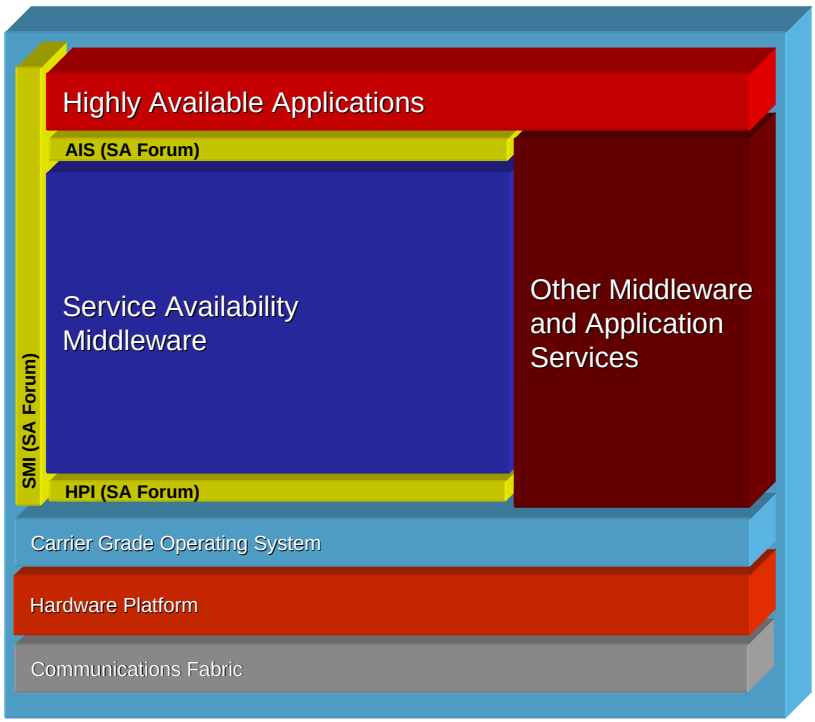
SA Forum Standard Interface Specifications

Application Interface Specification (AIS)

Hardware Platform Interface (HPI)

Systems Management Interfaces (SMI)



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THE AIS SPECIFICATION

Using SA Forum's specifications to build highly available services

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Application Interface Specification

- ***The Application Interface Specification (AIS) is a set of open standard interface specifications***

- ***The AIS specifies***
  - the Application Programming Interface (API) for HA middleware services
  - service entities and their behavior (life cycle, administrative operations, functionality)

- ***Example for specification/implementation***
  - HW interface: SATA
  - HW implementation: manufactured mainboard
  - HW user: the HDD (Samsung, Western Digital, Seagate, Hitachi…)

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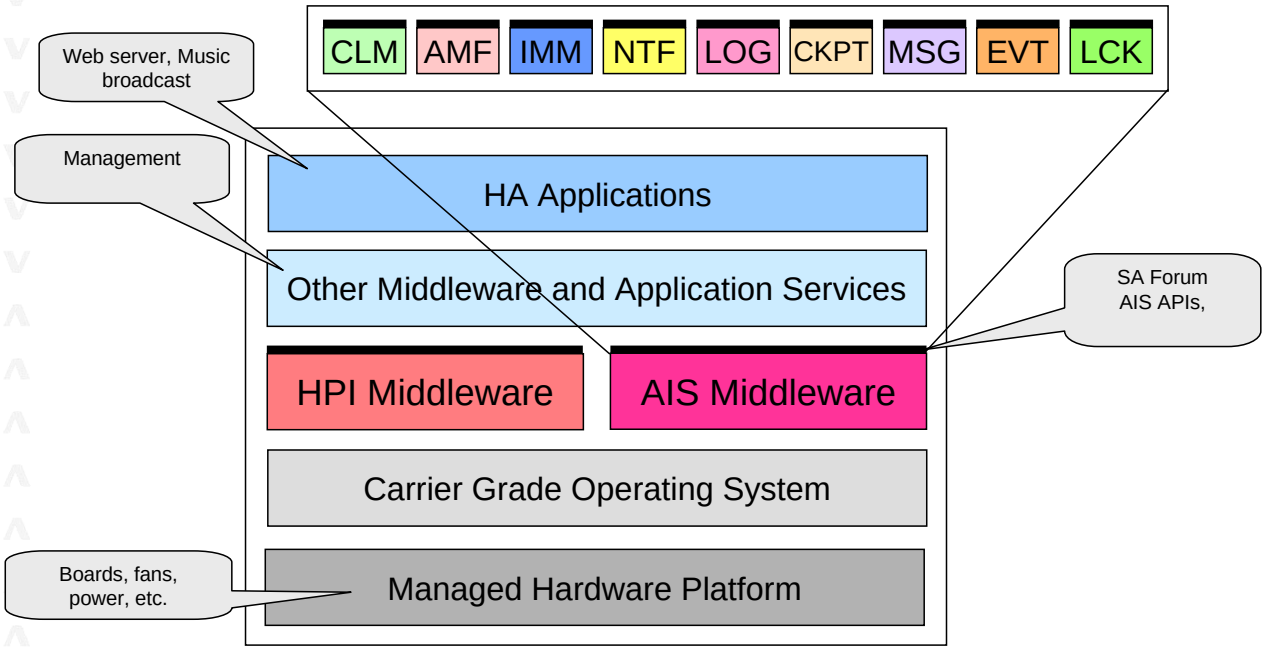
Application Interface Specification



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Application Interface Specification

- ***The AIS is divided into the following parts or areas***

- ***Administration***
  - Software Management Framework
  - Information Model Management Service
  - Cluster Membership Service
  - Notification Service
- ***Dependability***
  - Availability Management Framework
  - Checkpoint Service
- ***Communication***
  - Event Service
  - Message Service
- ***Miscellaneous***
  - Lock Service
  - Log Service

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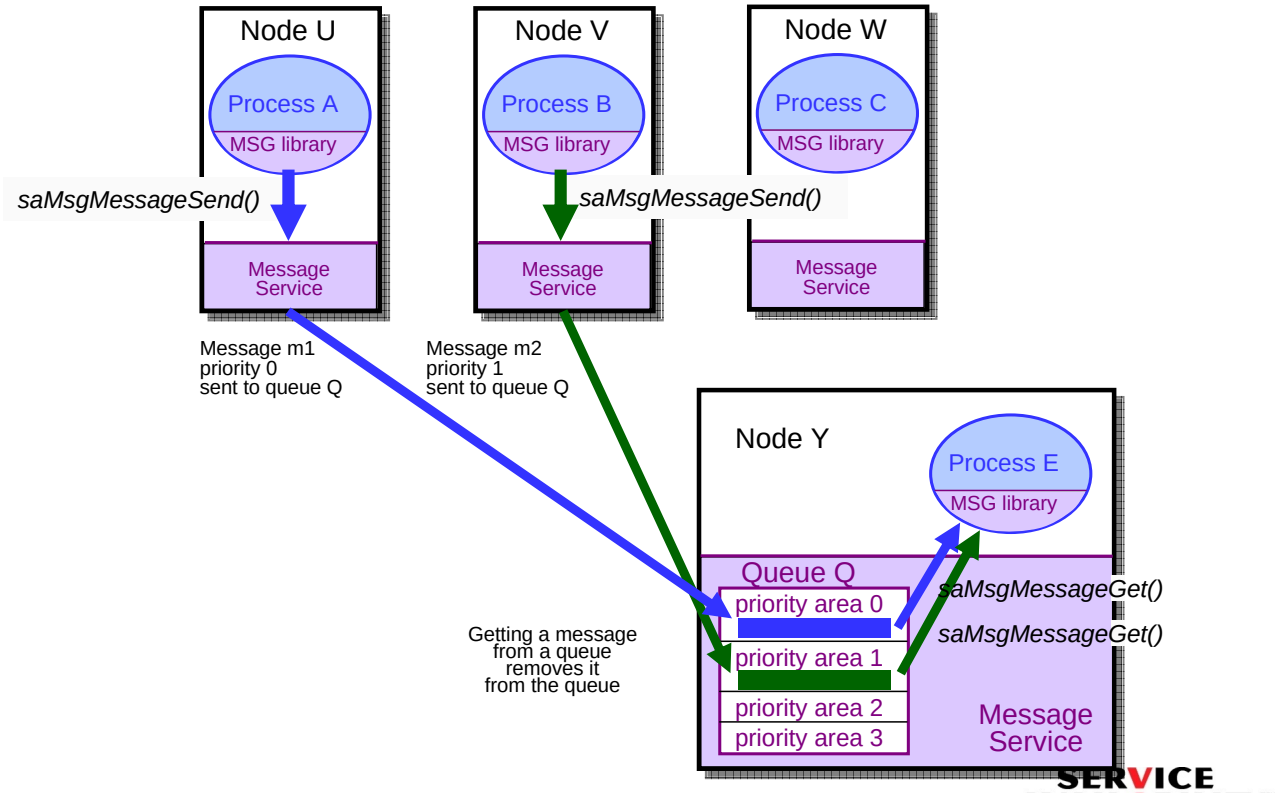
Example service - Message Queues



THE AIS SPECIFICATION

Dependability Services

SA Forum's approach to making applications HA

- ***Availability Management Framework principles***
  - Integrate best practices into the middleware,
  - Provide means for the software developer to influence behavior
  - Let the middleware control the application (like a Marionette)

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SA Forum's approach to making applications HA

- **Fault prevention**
  - Reduce the probability of system failure to an acceptably low value
- **Fault tolerance**
  - Provide service in spite of faults
- **Fault removal**
  - Diagnostics, monitoring, repair at development and runtime
- **Fault forecasting / prediction**
  - Estimating failures and their effects
  - E.g. software aging

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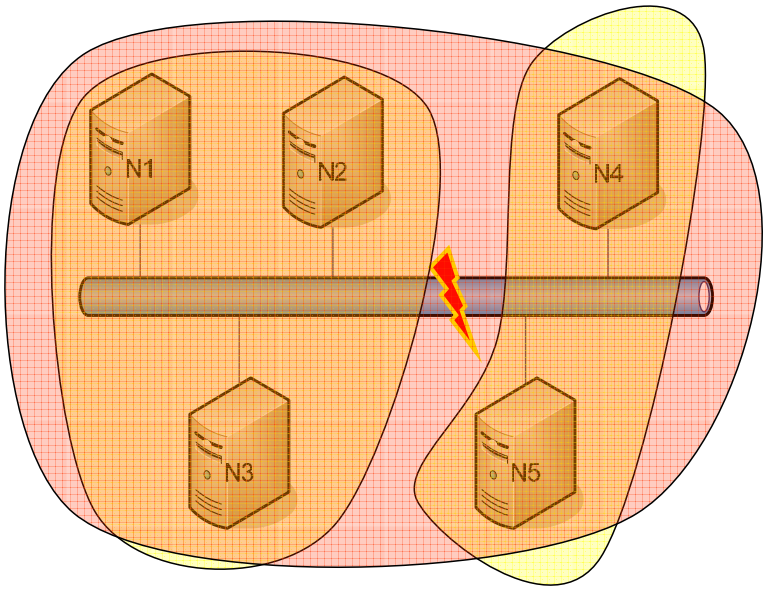
Server Clustering

- ***Notions***
  - node
  - link
  - cluster
  - partition
- ***Functionalities of cluster middleware***
  - Error detection
  - Error handling
  - Notification
  - Reconfiguration



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Server Clustering 2.

- ***Categories of clusters***
  - HA clusters
    - Improve the availability of services
  - Load-balancing clusters
    - Share the workload among the nodes
  - High-Performance Clusters (HPC)
    - Scientific computing
  - Grid computing
    - Many independent jobs

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HW and SW based Fault Tolerance

- ***HW***
  - Redundant power supply
- ***SW***
  - Process replicas, failover, switchover…
- ***Clusters – hybrid solutions***
  - Process replicas on different nodes

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AMF Redundancy Patterns

- ***Provided models***
  - 2N
    - Simple failover pair
  - N+M
    - Load balanced active servers and hot-standby units
  - N-Way
    - Load balanced active servers which are able to overtake the each other's services
  - N-Way Active
    - No standby redundancy is needed but processing has to be carried out in parallel by N service units
  - No redundancy
    - Non-critical services of the system

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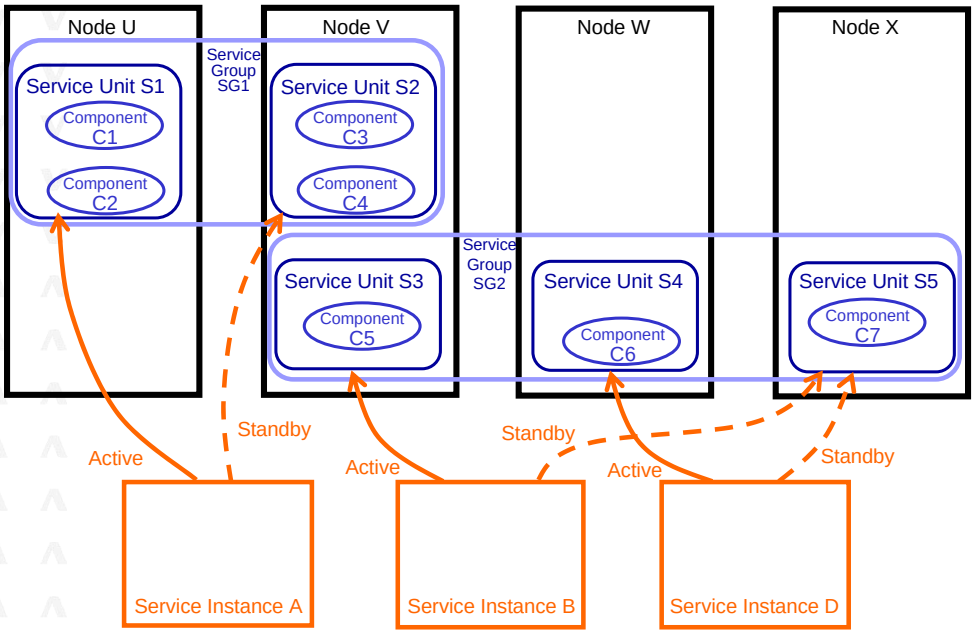
AMF System Model Example



Service group SG1 supports a single service instance A, and service group SG2 supports two service instances B and D

On behalf of A, service unit S1 is assigned the active HA state and service unit S2 is assigned the standby HA state

Service unit S1 contains two components C1 and C2, and service unit S2 contains two components C3 and C4

Similarly, for service group SG2

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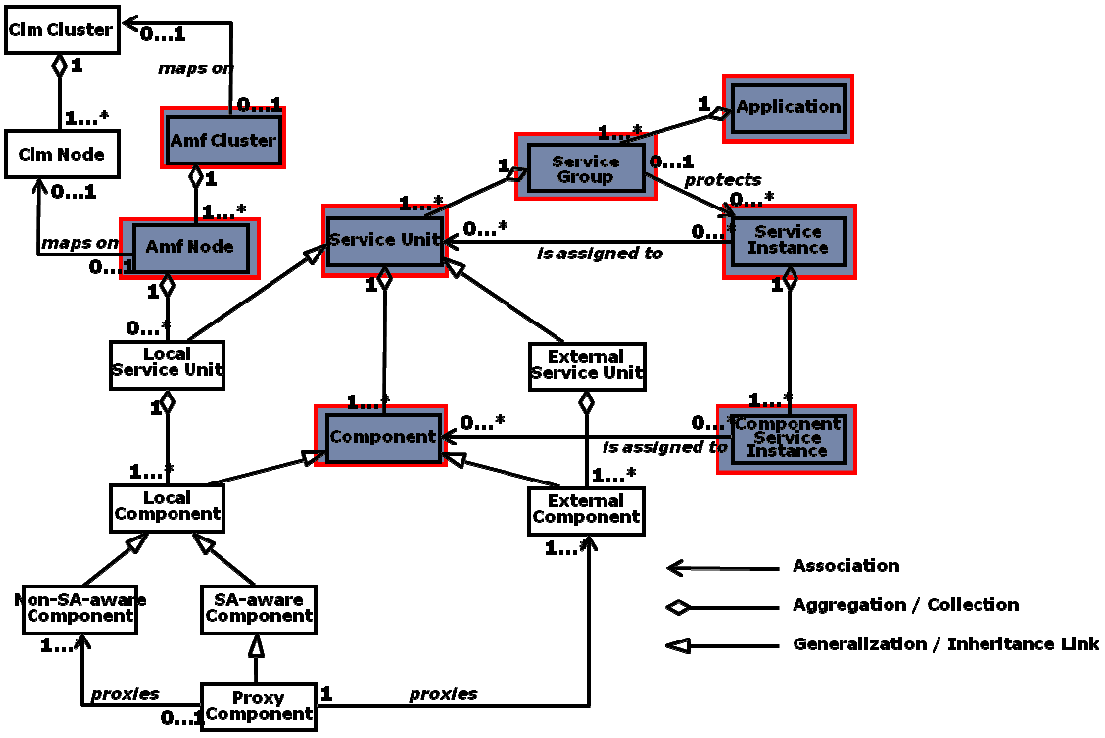
The SA Forum Information Model



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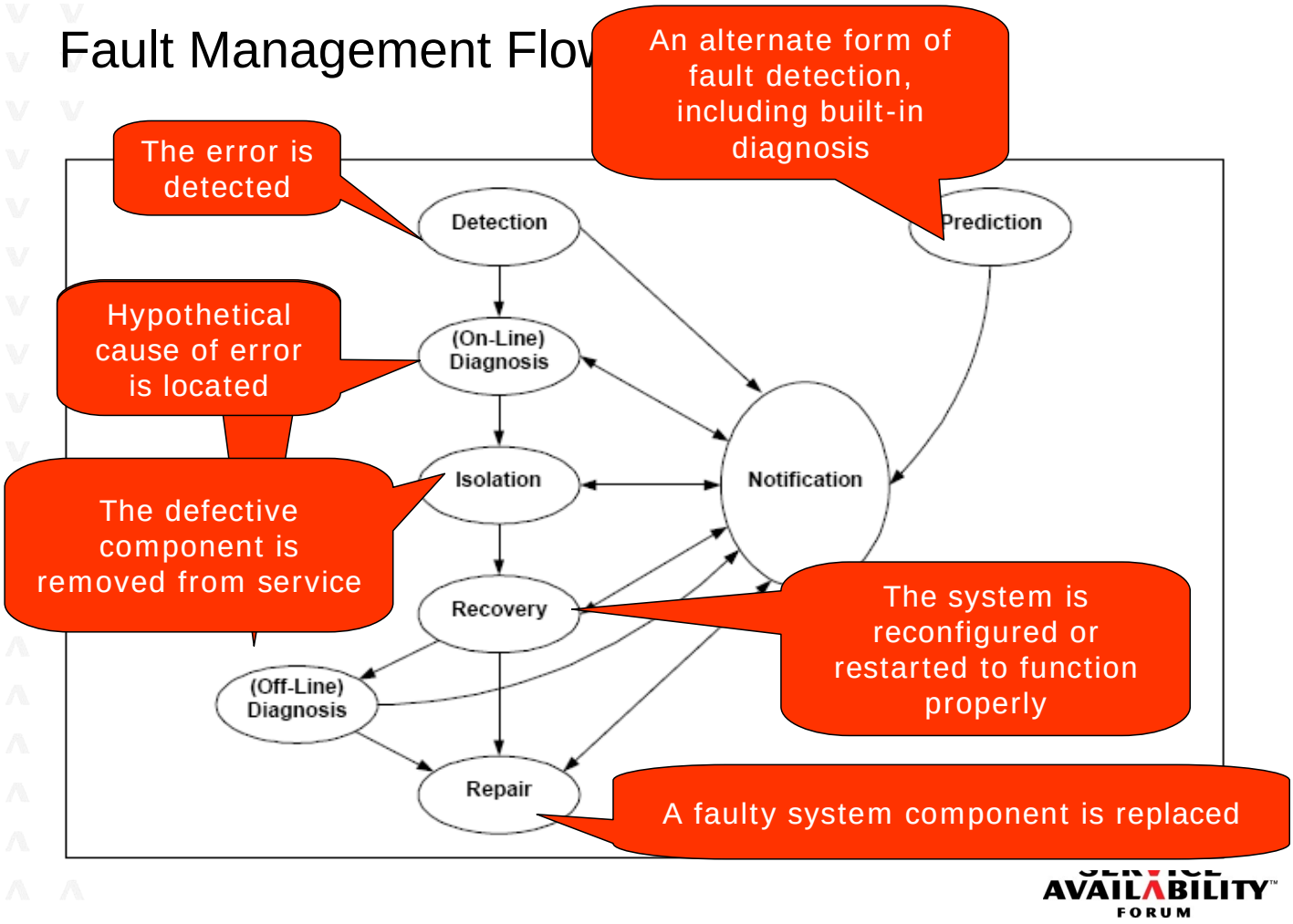
Fault Management Flow



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Error detection methods

- ***Mechanisms***
  - Interface check (e.g. illegal instruction, illegal parameter, insufficient access rights)
- ***Ad-hoc methods***
  - Acceptability testing
  - Error checking codes
  - Timing checks (watchdog)
  - Diagnostic analysis (in idle time)
  - Substitute back (integrate → derive)

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AMF error detection mechanisms

- ***Passive monitoring*** — Needs the change of the component ✗
  - Using OS functionality
  - Currently only crash of a process
- ***External active monitoring*** ✗
  - External entity is used to monitor
- ***Internal active monitoring*** ✓
  - Healthchecks
  - Types
    - Pull: AMF invoked
    - Push: Component invoked

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Planning recovery - checkpointing

- ***Define the variables to be saved***
  - State variables
- ***Normal operation***
  - Open checkpoint
  - Save variables regularly
- ***On failure***
  - Read checkpoint
  - Continue normal operation

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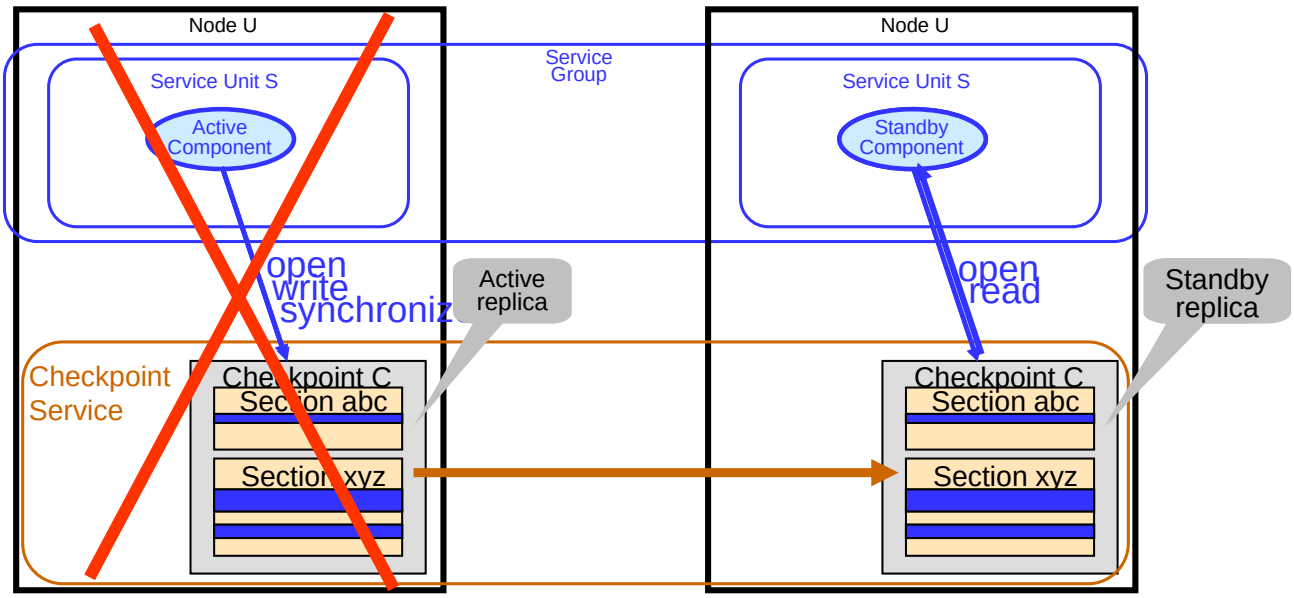
Checkpoint Service

- ***Example of checkpointing, and restoration from a checkpoint after a fault, for a collocated checkpoint***



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Methods of recovery

Goal: Recovery from errors before failures.

- ***Trivial methods***
  - Retry operation
  - Restart the application (cold, warm)
  - Restart the system
- ***Techniques***
  - Forward recovery
  - Backward recovery
  - Compensation

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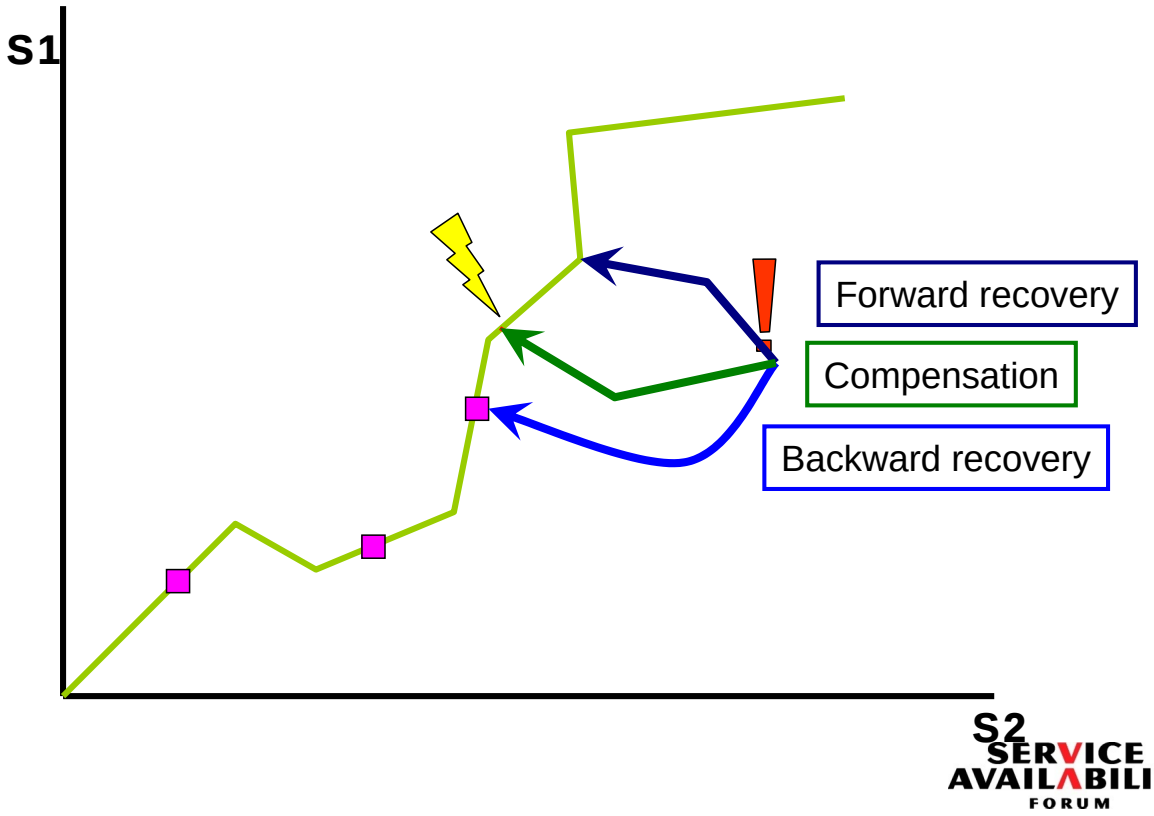
Methods of recovery 2.



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Rollback / backward recovery

- ***Preconditions***
  - State restoration is possible
  - Correct saved state
  - Logged interactions with the environment
  - Deterministic restart from a given state (distributed systems)
- ***Mechanisms***
  - State based rollback
  - Operation based rollback
  - Hybrid rollback (state + operation)

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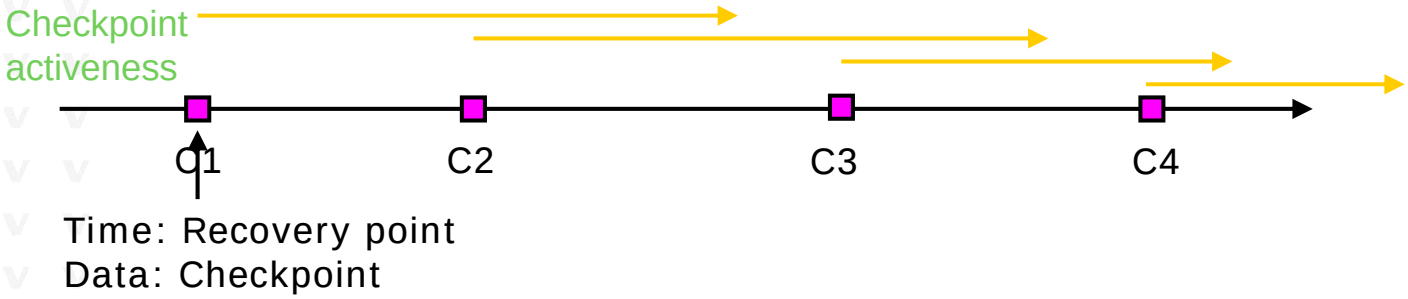
State based rollback



- ***Checkpoint operations***
  - Create
  - Discard
  - Rollback recovery
- ***Timing / triggers***
  - Time interval, number of messages sent, etc.
- ***Recovery region***
  - Active checkpoint exists
  - Recovery regions can overlap

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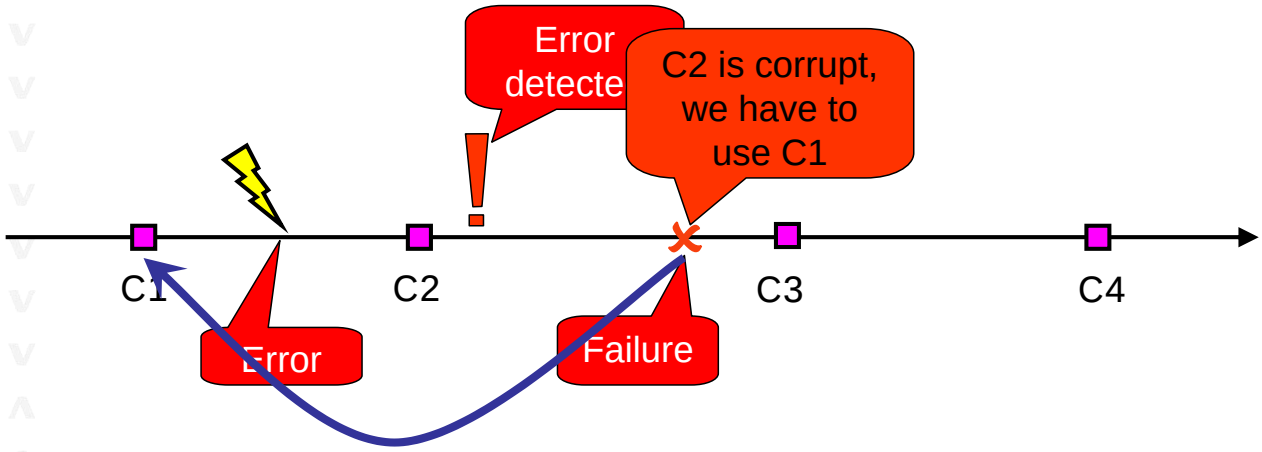
State based rollback



- ***Errors between state saves → 2 phase checkpointing (2 buffers)***
- ***Factors that influence # of overlapping rec. regions***
  - Error detection latency
  - Cost of buffers
  - Coordination in distributed systems

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Service continuity

Goal: maintain the service continuity

Type of error	Related actions
Transient	•Ignore (recovery handles them)
Permanent	•Reconfiguration •Failover •Switchover •Fail-back •“Graceful degradation”

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Actions

- ***Failover***
  - The service is removed from the failed entity and assigned to a healthy entity
- ***Switchover***
  - The service is removed from a healthy entity to another healthy entity
- ***Fail-back***
  - The failed entity is repaired and service is assigned to it again
- ***Graceful degradation***
  - Service is carried on in a degraded state, probably with degraded functionality

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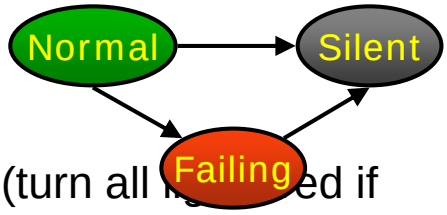
System level error handling patterns

- ***Fail-silent***
  - If failed then no messages are sent out until repaired
  - E.g. in distributed systems
- ***Fail-stop***
  - Stop operation on failure
  - E.g. train traffic control systems (turn all lights red if failure happens)



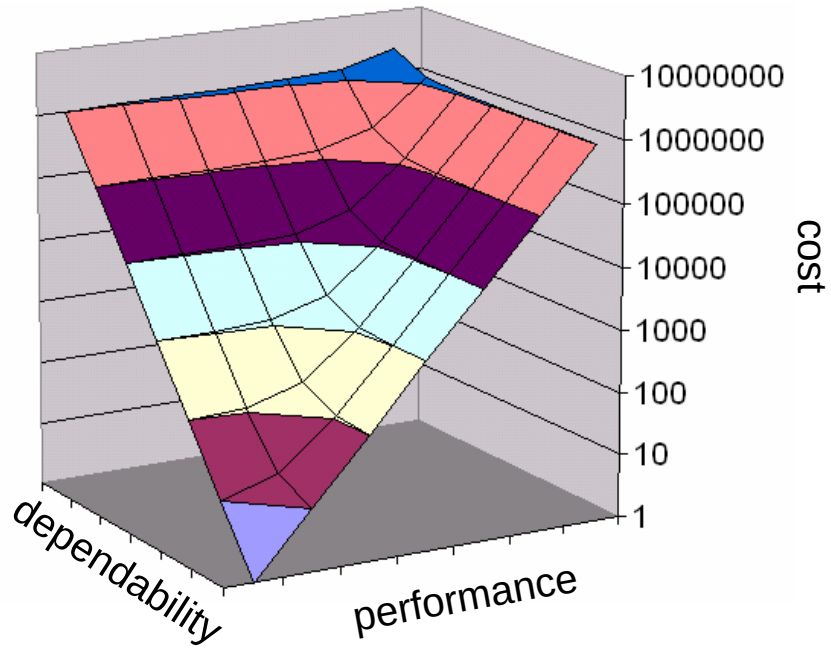
Francisco V. Brasileiro et. al. Implementing Fail-Silent Nodes for Distributed Systems (1996)

Requirements in today's systems

- ***Cost efficiency***
- ***Flexibility***
- ***Dependable services***
  - Highly Available
  - Reliable

Availability	Outage duration per year
0.99999	~5 mins
0.9999	~52 mins
0.999	~8 hrs
0.99	~3 days

Dependability and performance vs. costs



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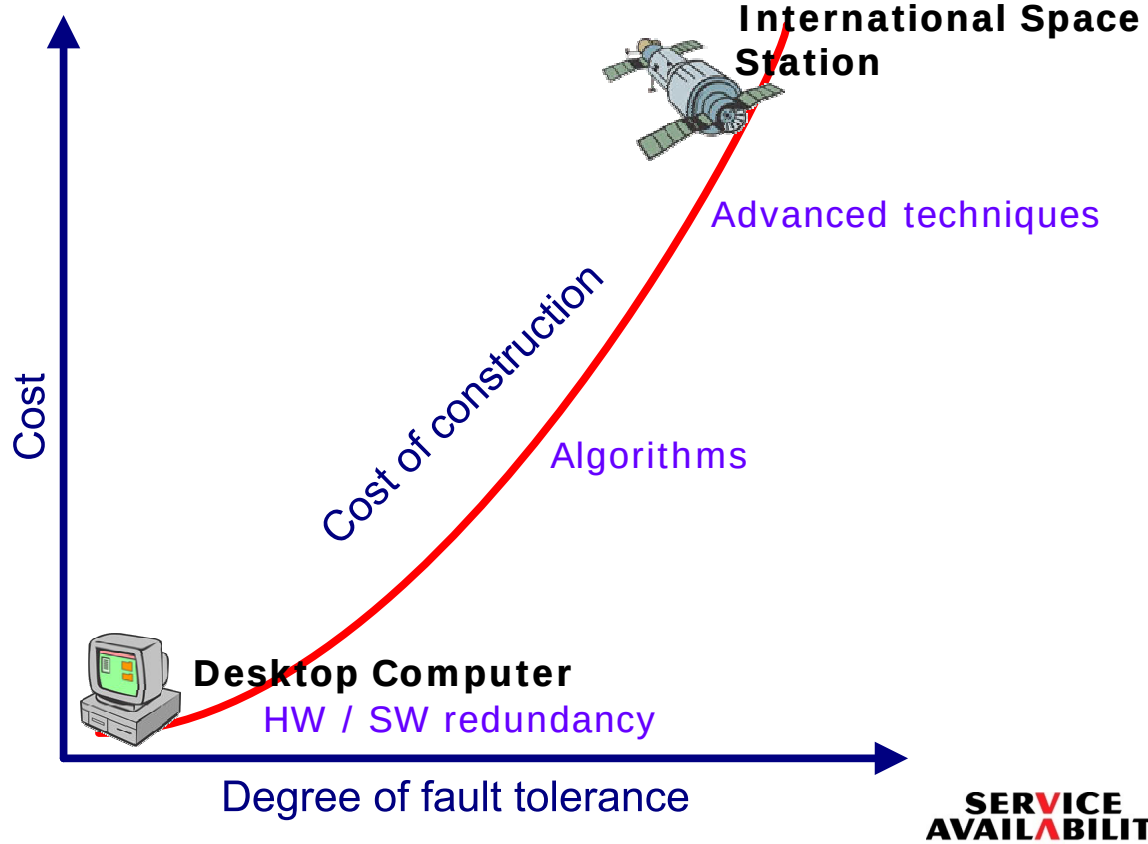
FT vs. Cost



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THE AIS SPECIFICATION

Communication Services

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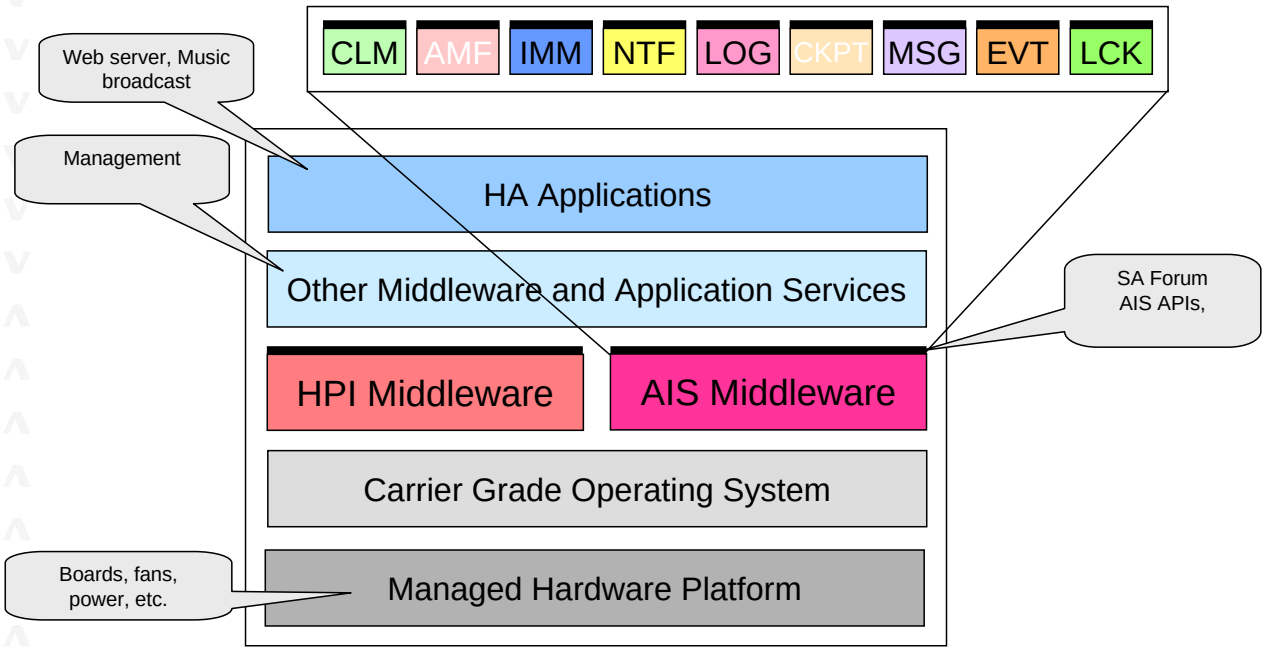
Application Interface Specification



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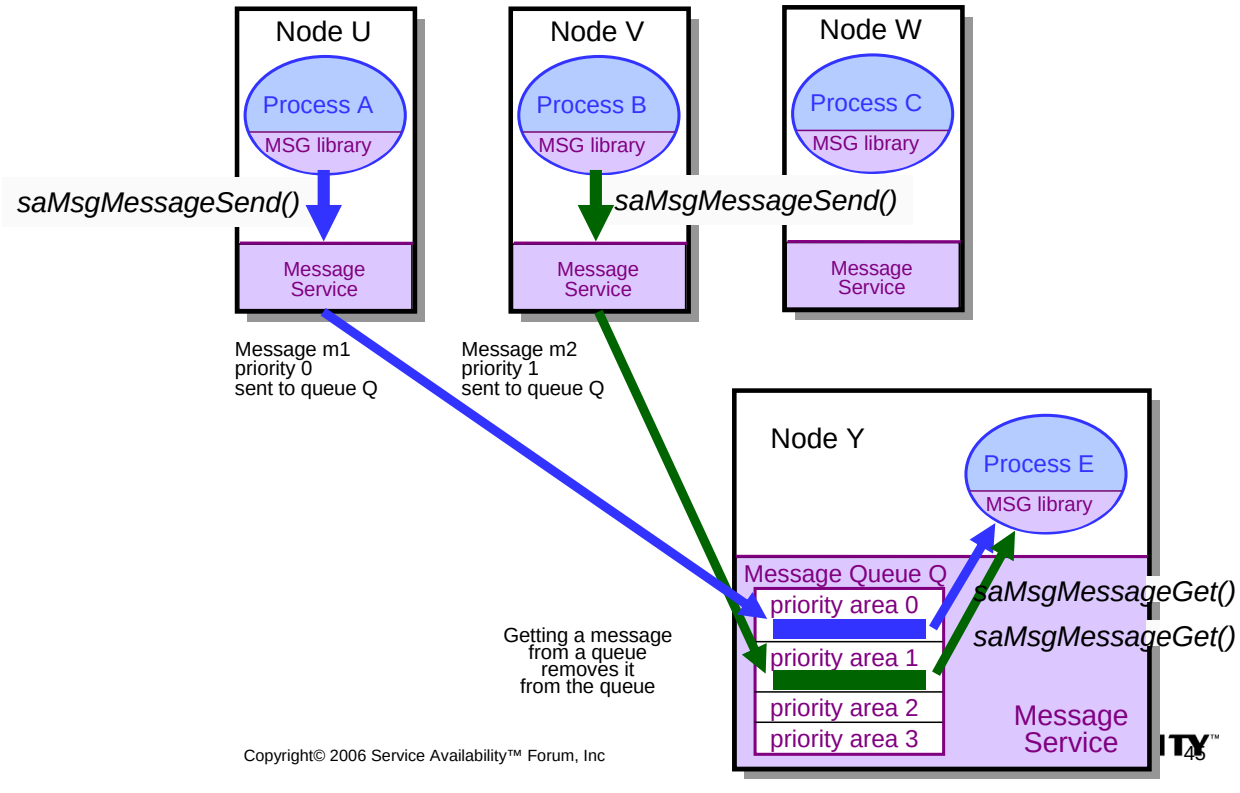
Communication

- ***Message (MSG)***
  - Recommended for many to one scheme
  - Example: collect sensor data
- ***Event (EVT)***
  - Many to Many (publish – subscribe) scheme
  - Example: Sentinels and villagers

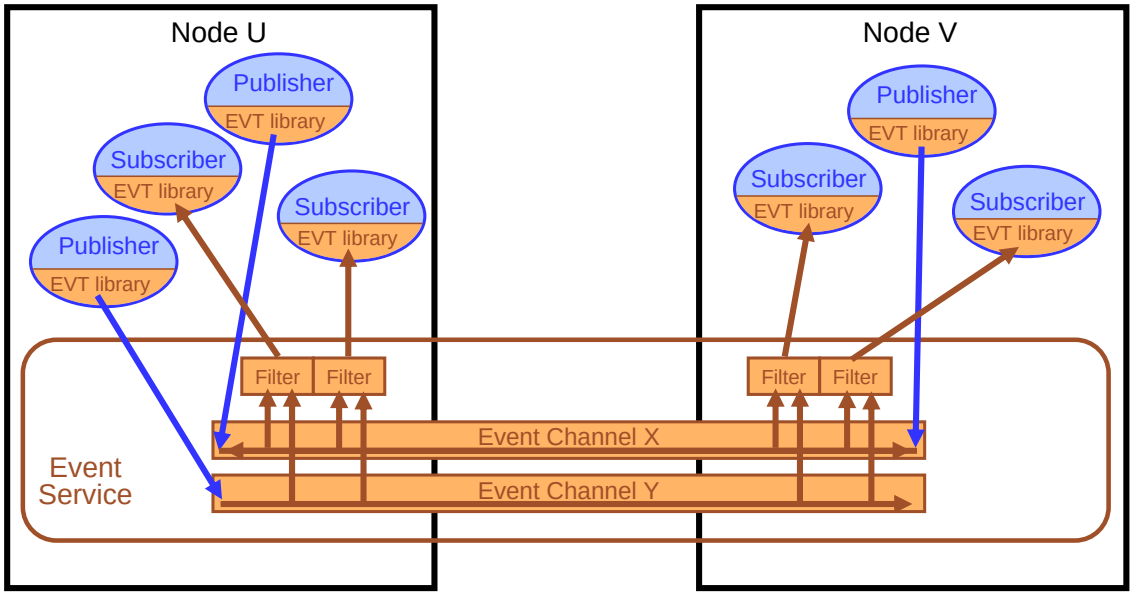
Message Service

- ***Message Service, Message Service (MSG) Library, and Message Queue***



Event Service

- ***Example of the Event Service, with publishers and subscribers on two nodes***



THE AIS SPECIFICATION

Programming model

Programming model

- ***Library life cycle***
  - Initialize, finalize, dispatch events
- ***Service specific APIs***
  - Callbacks
  - Request functions

Programming model - AMF

- ***Library life cycle***
  - *saAmfInitialize(), saAmfFinalize(), saAmfDispatch()*
- ***Service specific APIs***
  - Callbacks
    - *saAmfCSISetCallbackT()*
  - Request functions
    - *saAmfHAStateGet()*

Programming model – how to use it?

- ***Initialize service handler***
  - *saAmfInitialize()*
    - Set callbacks
- ***Get selection object***
  - *saAmfSelectionObjectGet()*
- **Start main loop**
  - do {
    - select(amfSelectionObject,…)
    - saAmfDispatch()
  - } while (1)

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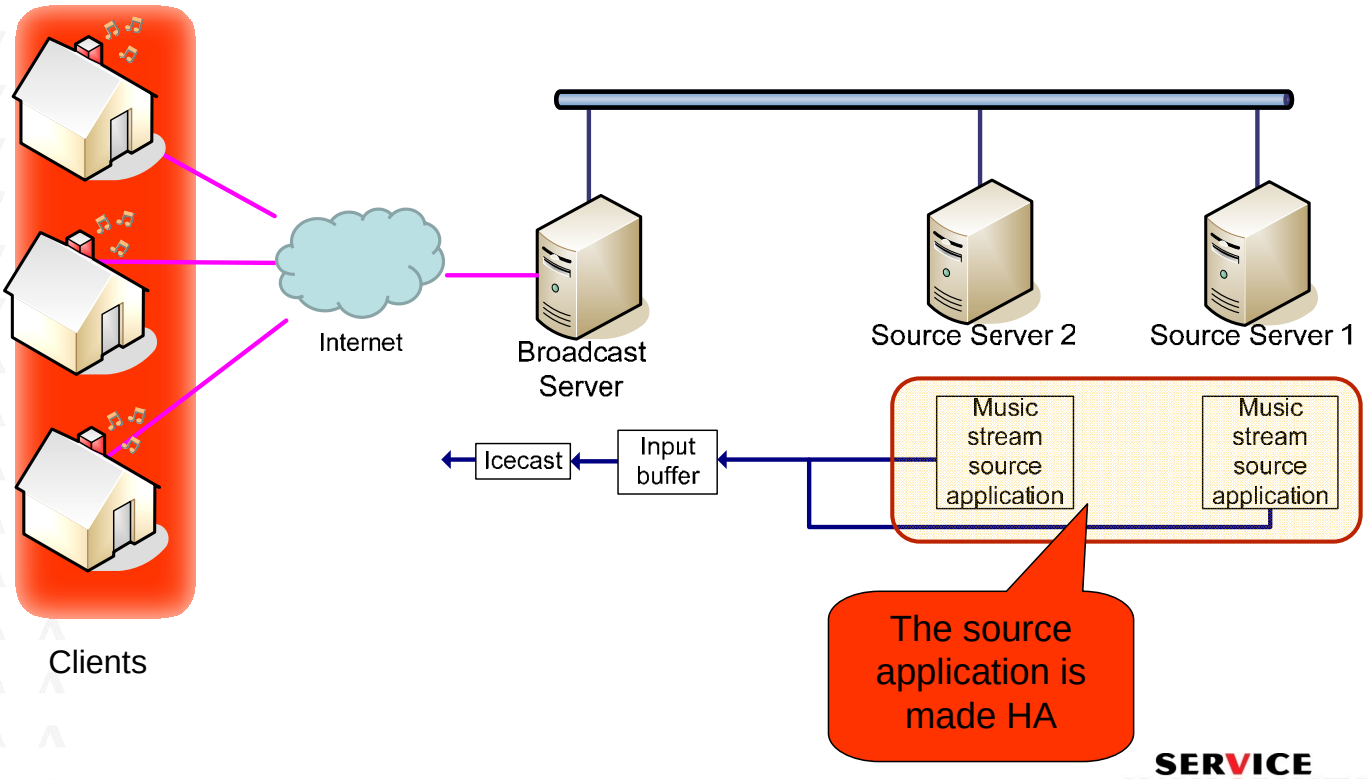
Demo

Highly Available / Fault Tolerant
Music Broadcast Application

Architecture



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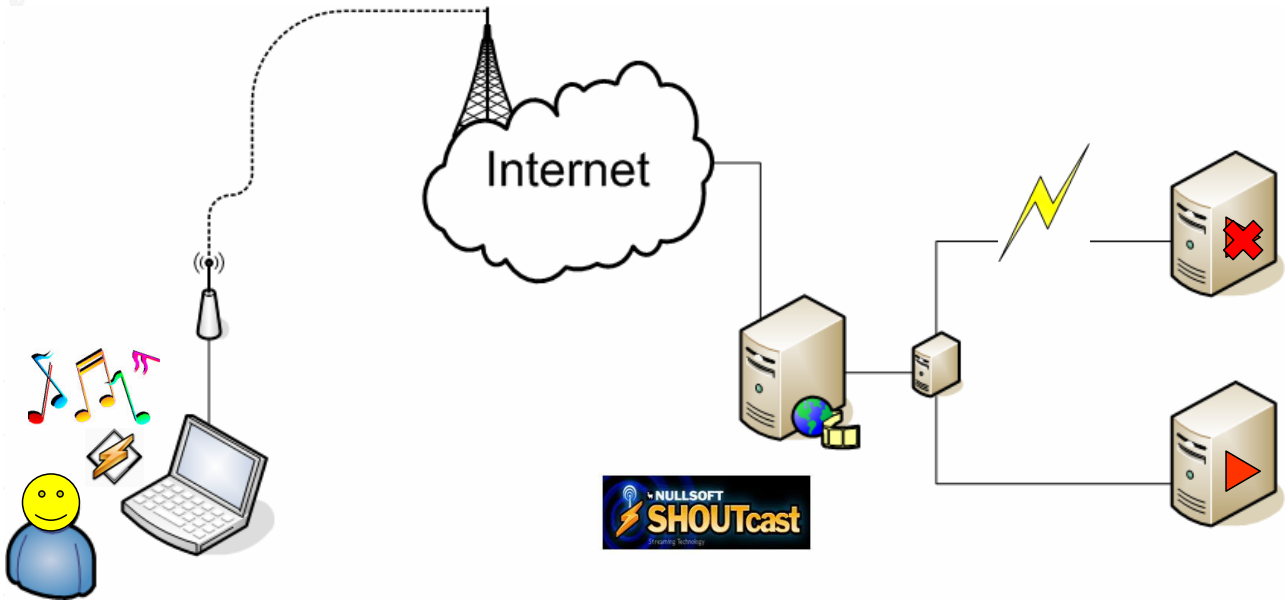
Online radio streaming system



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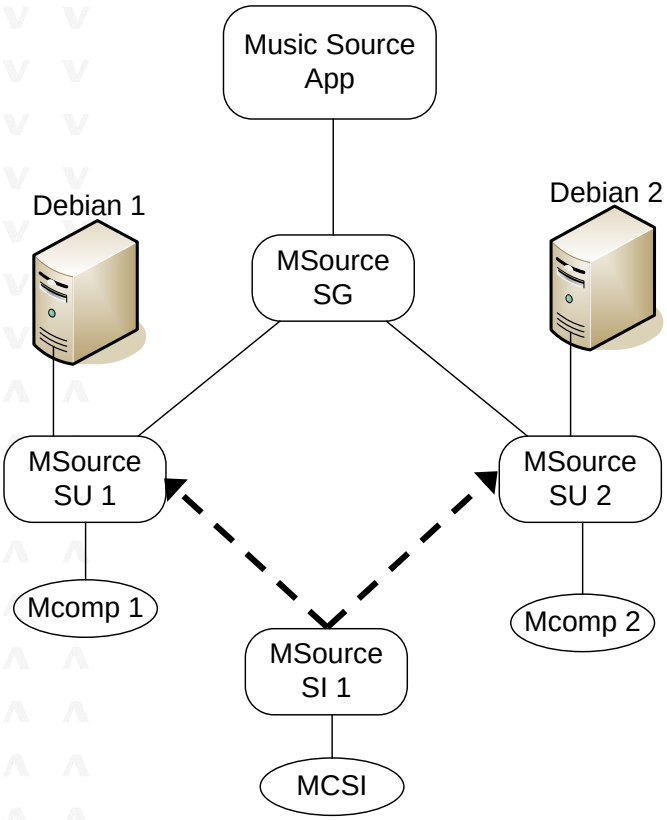
AMF configuration



- ***Tolerated failures***
  - Component
  - Node
  - One communication channel

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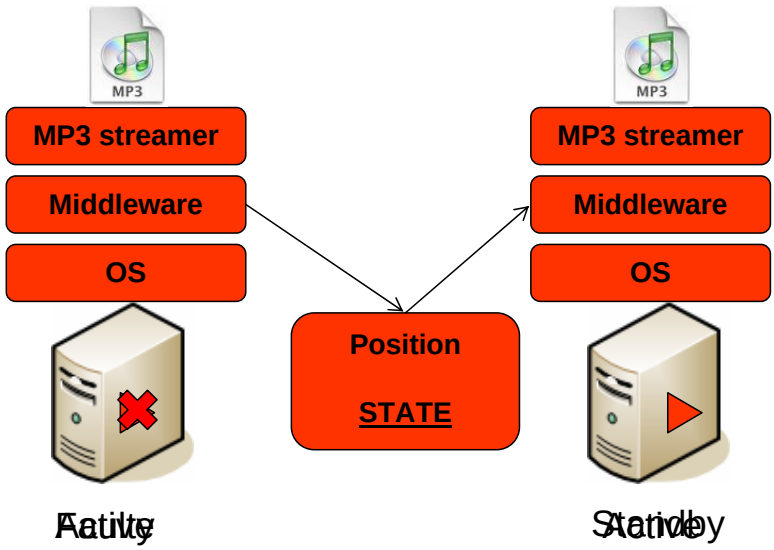
Where should I continue?



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Acknowledgements

- ***András Kövi*** 
- ***Zoltán Micskei,*** 
- ***István Majzik*** 
- ***András Pataricza*** 

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References

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    - http://www.saforum.org/education/
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  - http://www.inf.mit.bme.hu/FTSRG/

FAULT TOLERANT SYSTEMS RESEARCH GROUP

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