MISSION SOLUTIONS ENGINEERING

Employing the SAF Standard in the Defense Domain

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Aegis Open Architecture (AOA)

- Aegis Open Architecture goals
  - Provided opportunity to modernize the Aegis Weapon System design
  - Re-architect applications to improve openness and modularity
  - Employ COTS products when possible and practical for system services
  - Unify a fault-tolerant design across subsystems

Open Architecture System Management (OASM)

- OASM Goals
  - Improve consistency of and access to system status information
  - Modernize approach to managing COTS computing equipment
  - Modernize the approach to Application Management
    - Provide framework for fault-tolerant application designs
    - Employ COTS high-availability software if possible and practical
    - Adhere to industry standards

OASM Application Management Scope

- Configure applications & computing nodes into a system
  - Define SW hierarchy, redundancy models, SW assignment to nodes
- Launch, monitor, terminate SW components
- Recover from HW & SW failures
  - Form & monitor computing cluster (from configured nodes)
  - Assign/re-assign active & standby roles for SW components
  - Clean up after erroneous SW component terminations

OASM Application Management Scope (continued)

- Attempt repair (restart/reboot) to reinstate SW components & nodes

- Interface to management clients
  - Provide SW & node cluster structure & status
  - Provide administrative controls (startup, shutdown, repair)

- Provide High Availability (HA) services to running SW components
  - Component cooperates with OASM in monitoring its own health
  - Component receives its HA state (active or standby) from OASM
  - Component issues & subscribes to notifications via OASM
    - Abnormal & state-change events
  - Component can obtain any subsystem's availability state from OASM

Open Standards Analysis

- A set of evaluation criteria was established
- Each standard was evaluated in terms of its ability to meet that criteria
- Example criteria:
  - Ability to logically group applications
  - Ability to start/stop applications in groups
  - Allow user specification of application dependencies
  - Support application failovers
- A Service Availability Forum (SAF) standard was ultimately selected based on the evaluation criteria

Service Availability Forum (SAF)

- The SAF is a consortium that promotes open standards for mission critical systems

- The SAF's goals align well with DoD goals:
  - Faster time to market for applications
  - Reduced life-cycle costs
  - Simplified introduction of "best in breed" software components
  - "There is no upside to downtime"

- SAF spec is comprised largely of two specifications:
  - Hardware Platform Interface - HPI
  - Application Interface Standard - AIS

SAF Application Interface Specifications

AIS Specifications	
Cluster Membership Service	Availability Management Framework
Notification Service	Event Service
Checkpoint Service	Log Service
Information Model Management	Messaging Service
Naming Service	Platform Management Service
Security Service	Software Management Framework
Timer Service	Lock Service

Visit http://www.saforum.org for all SAF specifications & tutorials

OASM Application Management and the AIS

- OASM App Mgmt is based on the Service Availability Forum (SAF) Application Interface Specification (AIS), version B.02.01, January 2005

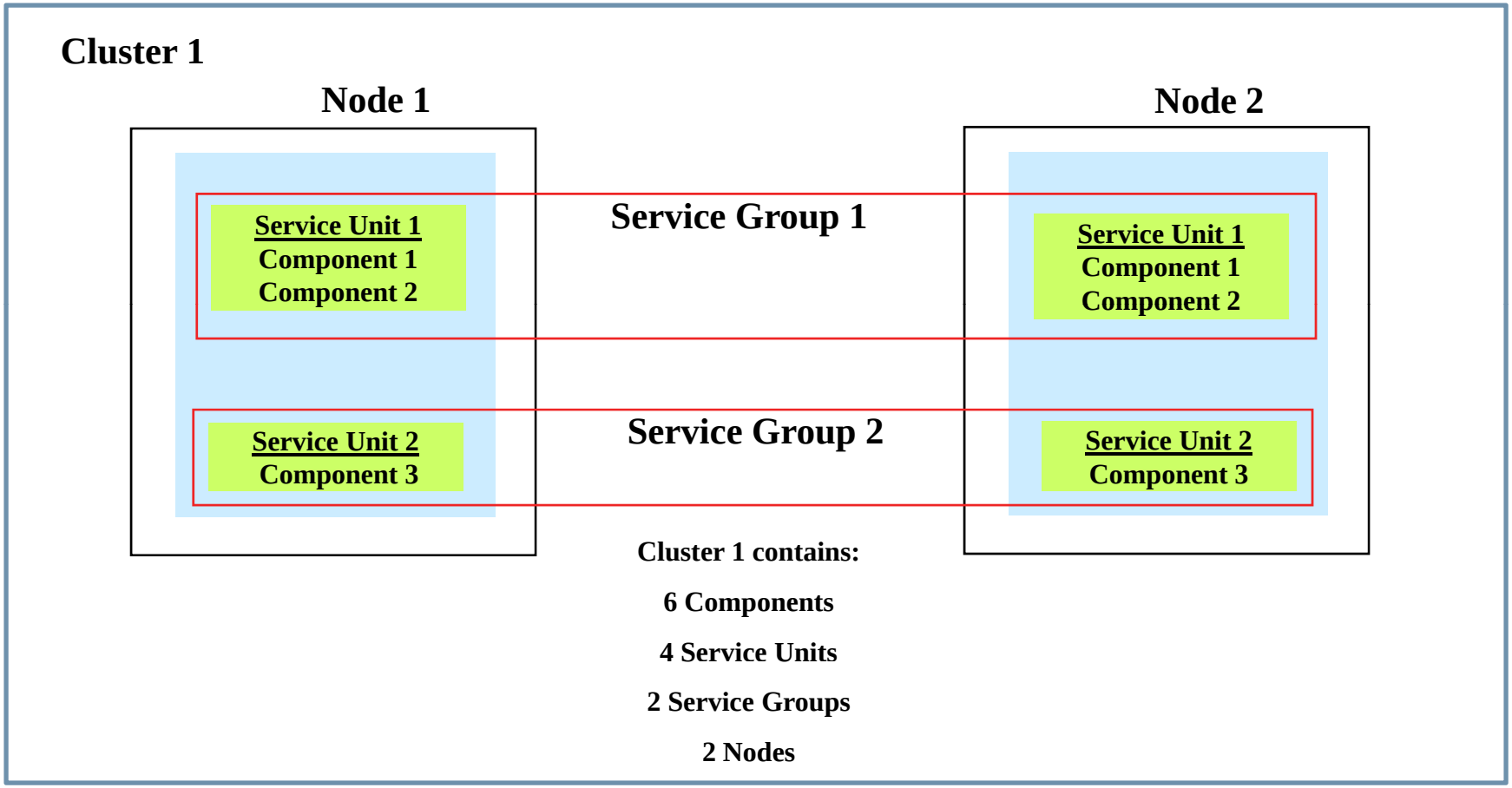
- The AIS Availability Management Framework (AMF)
  - Specifies a high availability model, redundancy models, auto-repair behaviors
  - Specifies an application API for HA management

- The AIS Notification Service was also implemented

Key Concepts in AIS

- Computing Cluster
  - Physical nodes that correspond to actual machines
- Components
  - Generally one or more software processes (as in Unix/Linux)
  - Lowest level of managed entity recognized by AMF
- Service Units
  - Composed of one or more components
  - Assigned service instances (work units) by the AMF
  - Can be configured to have redundant instances for fault-tolerance
- Service Groups
  - Collection of Service Units that protect service instances against failures
  - Characterized by a SG Redundancy Model (2N, M+N, etc.)

Example Cluster



COTS Product Evaluations

- A set of evaluation criteria was established
- Products were initially evaluated with test applications in an unclassified environment
  - Evaluation included both functionality and performance
- Examples of important criteria:
  - Extensibility of the product
  - Ability to set thread priorities
  - Customizable logging levels
  - Vendor’s presence in the marketplace
- A demonstration of candidate products was provided for the stakeholders

COTS Product Evaluation

- Ultimately GoAhead's SelfReliant product was chosen
- A SAF compliant product was on GoAhead's roadmap but their product development schedule and our ship delivery schedules did not align
- In reality we needed the product before it was commercially available

OASM Development

- In order to meet our schedule a custom solution was developed
- An OASM value-add layer was created to insulate the tactical applications from the underlying COTS product
- This layer provided:
  - SAF APIs to the tactical components
  - The ability to add instrumentation within the API
  - An adaptive layer for future COTS product insertion

OASM Development

- The OASM product extended the functionality of the basic COTS product in the following areas:
  - System Configuration files used to create the System Model are validated and parsed at system initialization
  - Nodes receive requests to start/stop applications from a centralized manager
  - Data recording of system events, state changes, etc.
  - System model data is published via SNMP for subsequent use by a control agent

Management-Client Interface

- Library of C++ classes providing access to OASM Management information
- Management information obtained via SNMP according to SAF MIBs
- The Management-Client interface provides access to a repository of system SAF objects
  - Finer granularity of information
- This interface provides the ability to modify an object's state within the model from an outside source

OASM Status Tracking Service

- A System Status Tracking capability was created to allow components to monitor other component's status
- This service composes SAF status into overall Up/Down for tactical components
  - Higher level of granularity of information
- The Status Tracking Service is not a SAF capability, but a derived capability crafted from SAF constructs

Notification Service

- The Notification Service is used by a component to send a system event notification to interested subscribers
- Notifications have built-in semantics that further define the type and reason for the notification. Our implementation utilized two SAF notification types:
- Alarms – examples:
  - Fatal exceptions
  - Loss of critical resource
  - Threshold limitations exceeded
- State Change – examples:
  - Initialization Complete
  - Channel Up
  - Operational Mode (Tactical, Training)

Notification Service

- Our implementation utilized DDS as the message transport
- Notifications are data recorded to aid in root/causal analysis
- Common classes of notifications were provided for users
- Reader utility classes are provided to allow for search and retrieval of notification data

Implementing the Product

- An OASM Integrated Product Team was established that was comprised of a design team, development team and integration team
- Weekly meetings with the tactical product areas were held to discuss requirements and the SAF adoption process
- The design team worked to ensure that the OASM requirements supported the product area requirements
- The development team created a product that provided the necessary abstractions between the SAF API and the SelfReliant product
- The integration team focused on lab activities and working with each product area to ensure successful integration of the product

Integrating OASM into the Tactical Product Areas

- Integrating OASM into the individual product areas was a challenging task
- Each product area contained a unique resource management implementation
- Some product areas were already componentized and easily adopted the new resource management scheme
- There were also several legacy applications that required some significant rework to integrate with OASM

Integrating Open Architecture Components

- Tactical applications that were designed with an open architecture philosophy were easily integrated
- Component based architectures fit well within the SAF
- Component dependencies were easily established
- Recovery designs were crafted from SAF capabilities

Integrating Legacy Components

- A subset of tactical applications were leveraged from prior development efforts
- These applications were based on legacy designs that contained proprietary resource management solutions
- Each application was modified to accept the new service
  - Remove legacy system management solution
  - Adding the new APIs
- In most cases the tactical applications had implemented a service layer for their resource management capability
- We found that legacy recovery requirements fit well within the SAF

Integrating Other Applications

- Some components could not accept the OASM API
  - COTS products with no access to source code
  - Legacy products used on other projects that did not have OASM as the resource management service

- A custom “wrapper” was developed to address these components and serves as a proxy
  - OASM launches and monitors the wrapper
  - Executable is launched via the wrapper
  - The wrapper executes the OASM API on behalf of the application

Deploying the Product

- The OASM product was successfully deployed on the USS Bunker Hill CG-52 as part of the Navy's Cruiser Modernization Effort

- OASM will be deployed as a part of the Aegis Modernization efforts on destroyers and cruisers

System Level Integration

- Integrating multiple product areas with OASM went fairly well
  - Minor network configuration changes needed
- Our system model became large and complex
  - Ultimately we revisited our node cluster organization
- OASM logs become critical for a first level assessment of multi-component failures
- Data recording of key events provides critical information for performance analysis and root cause analysis for failures

Summary

- Commercial standards may not fulfill all of your requirements
  - Standards can be augmented with “value add” services
- Look for COTS solutions that are extensible and mature
- Find vendors who are willing to modify their product when needed
- Evaluate the product in terms of its functional capabilities and performance to gain confidence in it
- Recognize that some components will have unique requirements and need to be managed differently
- Encourage design teams to meet often and openly discuss requirements
- Stand up an integration team and embed them with product developers

Acronyms

- AIS – Application Interface Specification
- AMF- Availability Management Framework
- AOA – Aegis Open Architecture
- COTS – Commercial off the Shelf
- DDS – Data Distribution Service
- HA – High Availability
- OASM – Open Architecture System Management
- SAF- Service Availability Forum
- SNMP – Simple Network Management Protocol

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