Project Shoal - A Generic Clustering Framework

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What is Project Shoal?

- A Java.net project aimed at building a Clustering Framework
  - for Java EE/J2EE Application Servers and any other product requiring clustering features
  - At https://shoal.dev.java.net
- Shoal provides a Group Management Service (GMS) that provides
  - group membership management through discovery of events
    - join, shutdown and failure notifications, delegated recovery initiation, and
  - state caching facilities
- Applications interact with Shoal's GMS API using their logical identity semantics to communicate with other group members

Shoal GMS Feature Themes

Three broad feature themes:

- Features providing
  - a group sensory-action theme.
  - a group communications theme.
  - Shared or Distributed Storage theme.

Shoal GMS Group Sensory-Action Theme

- Provides a set of Client APIs for signalling cluster events. Such Signals include
  - Lifecycle Signals
    - Cluster Member(s)
      - joining the cluster at runtime
      - leaving the cluster at runtime
      - going into in-doubt(suspected) state.
      - being confirmed failed
  - Recovery oriented Signals and Support
    - Automatic Recovery Member Selection Signal
    - Protective failure fencing operations

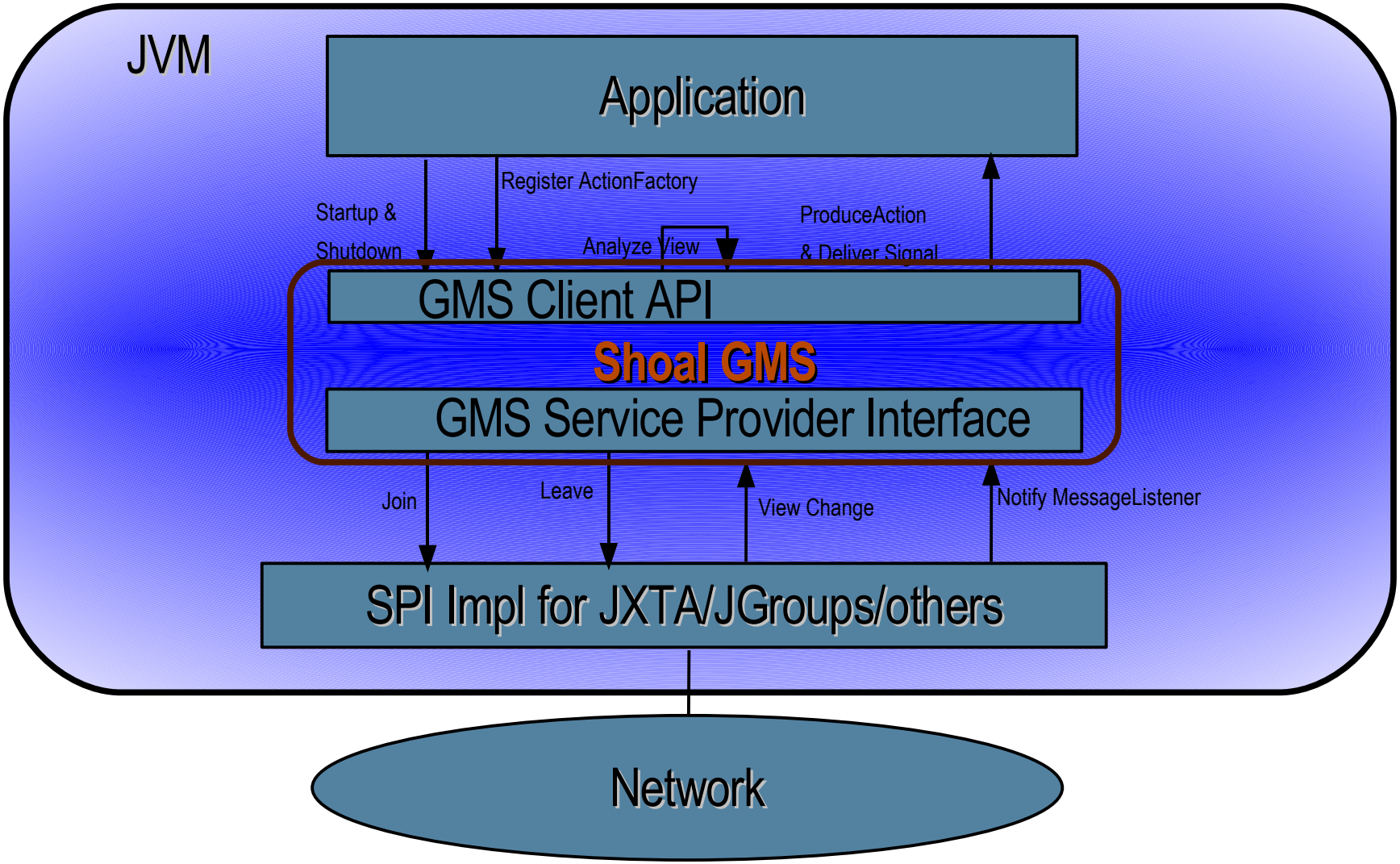
Shoal GMS Group Communication Theme

- GMS provides Group Communication Provider SPI
  - Group communication technologies such as JXTA, JGroups, etc. integrate through SPI
- GMS provides a group messaging handle
  - to clients to send messages to group or particular member(s),
  - client components can address messages to specific components in destination
- GMS hands Message Signals in recipient clients
  - GMS delivers the Signal to the target component

Shared or Distributed Storage Theme

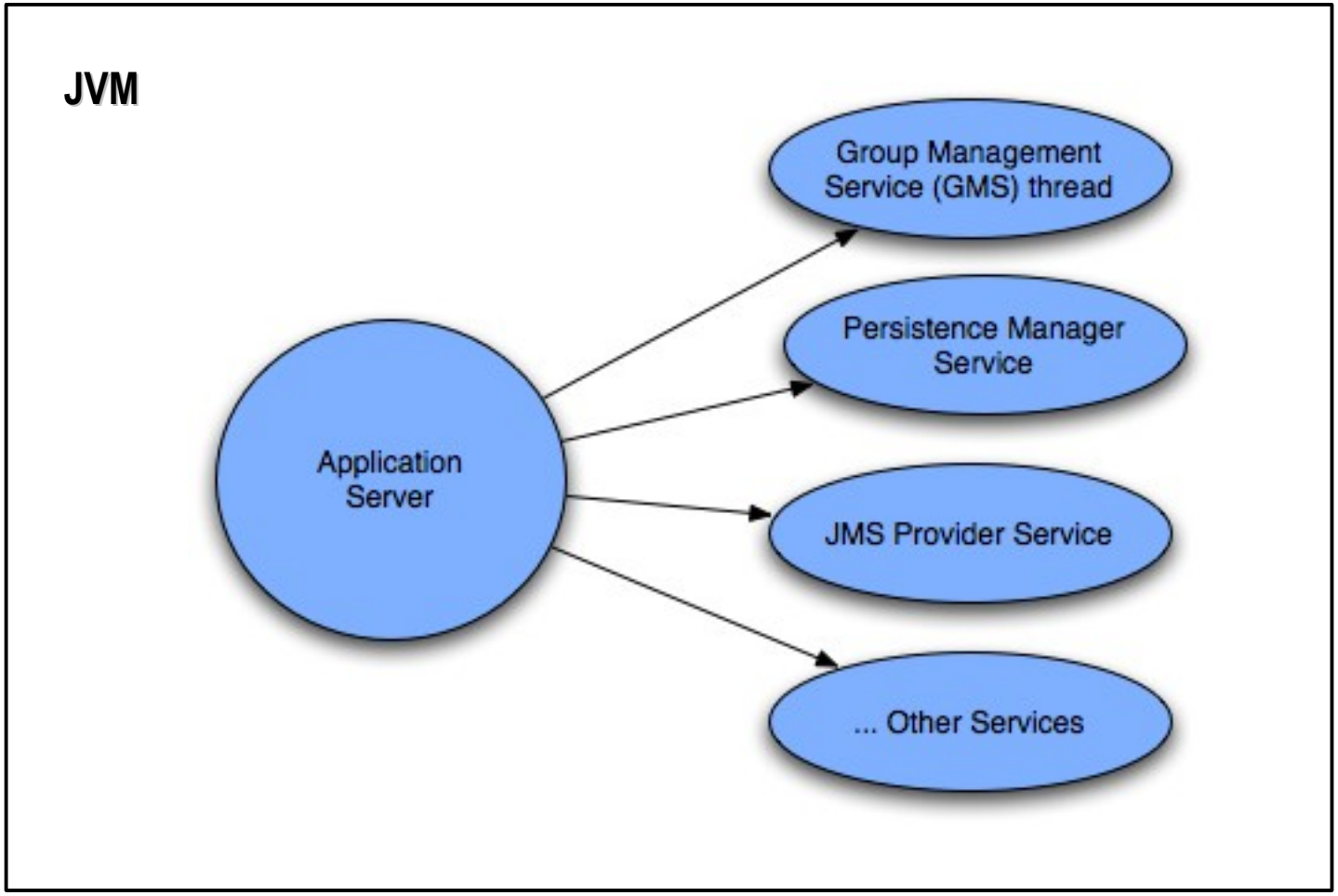
- GMS provides a Distributed State Cache (DSC) interface
  - Can be implemented to suit custom requirements
  - Default Implementation is a shared concurrent hashmap
- DSC can be implemented for in-memory shared/distributed cache for application state
- Group communication providers provide tunable performance properties for better throughput

Application, Shoal GMS, Group Communication Provider Relationships



Shoal GMS in Application Server Instance

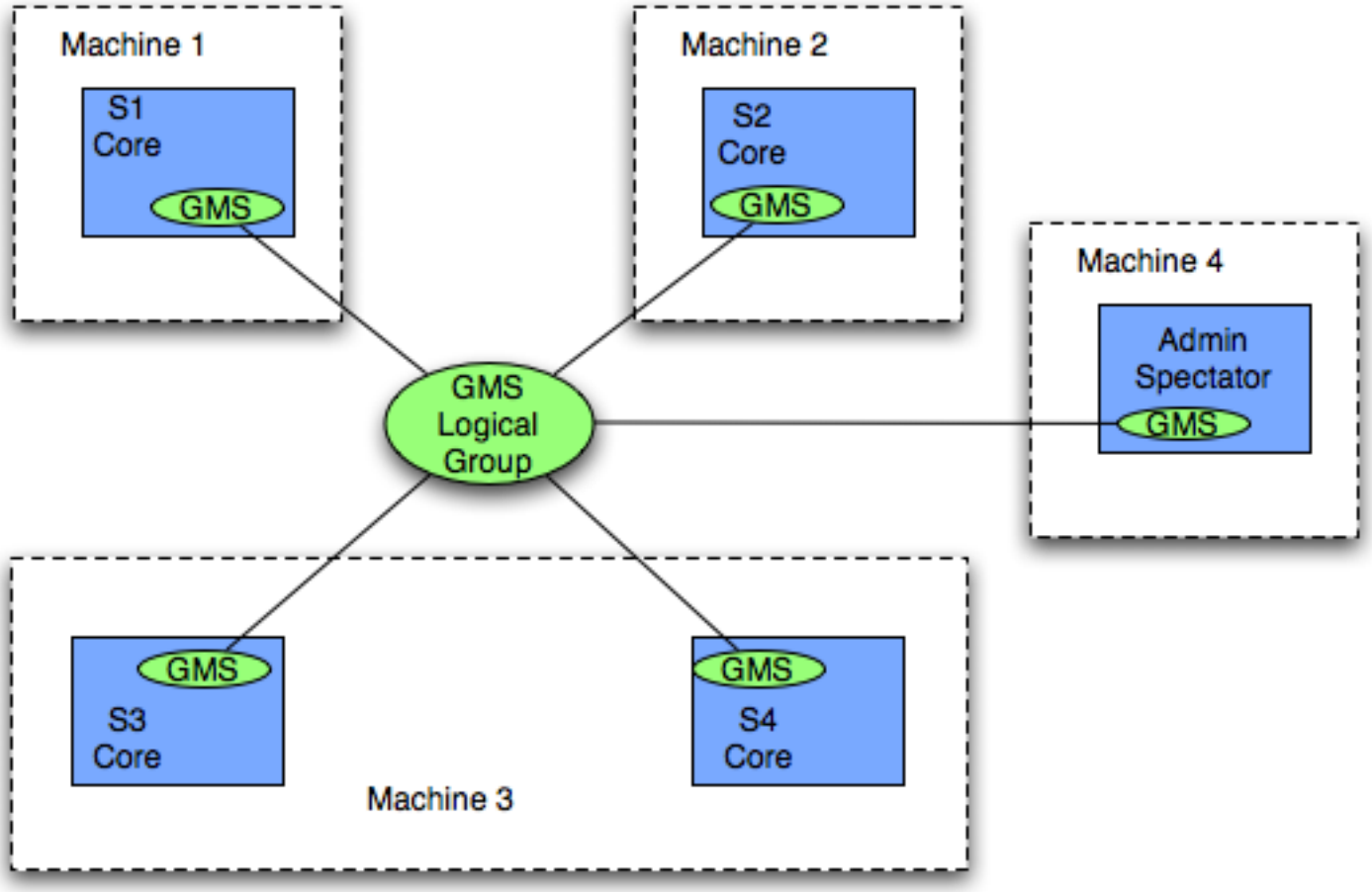
Application Server starts various in-process Services, one of which is the GMS



Shoal Group Management Service

- At startup, GMS in each process joins predefined group (and at shutdown leaves that group).
- Pluggable GroupCommunicationProvider Impl provide communication channels, and protocols for group composition and failure monitoring
- When member joins, leaves or fails, GMS calls client components informing them
- On failure confirmation, if enabled, Recovery Oriented Computing Support kicks in –
  - GMS selects a recovery candidate member
  - Notifies registered client components in selected member process
  - Shares this selection information through DSC.
  - Protects recovery operations through failure fencing
  - Ensures recovery-in-progress ops are tracked for multiple failures
- Provides a default Distributed State Cache implementation for caching recovery states and application lightweight data

Shoal GMS in an Application Server Cluster



What do Shoal GMS clients get?

- Peace of mind :)
- Saves many person years of work in writing complex code to emulate its functionality in common enterprise applications
- GMS takes on the complexity of group formation, discovery of members, preconfigured endpoint locational details, networking semantics
- Clients simply use the group's logical membership identities to communicate and be notified of events

What do Shoal GMS Clients get ?

- Allows client components in a process to :
  - Send and Receive Messages using app level addressing semantics ex. Using instance Id or name for addressing the destination.
  - Use GMS Event Model for receiving Group Event Notifications & Message Delivery
  - Use GMS APIs for getting member states, current group composition, caching app level information, and for messaging one-to-one, one-to-many, and one-to-all.
- Each system installation uses a particular Group Communication Provider, plugs in the same with SPI implementation. Clients don't change any code.
- Useful features yet a lightweight component providing an engine for building enterprise distributed systems functionality
- Recovery oriented computing semantics without application specific artifacts, a basis for building fault tolerance solutions.
- Several current use cases within Sun's Appserver, more to come...

Shoal GMS Startup code sample

```
public class GMSLifecycleManager {
    Runnable gms;
    public void startGMS(){
        try {
            //creates a Runnable and inits with serverId, groupId, membertype and lifetime
            //config properties.
            gms = GMSFactory.startGMSModule(serverId, groupName,
                GroupManagementService.MemberType.CORE, properties);
            Thread t = new Thread(gms, "GMSThread");
            t.start();
        }
        catch (GMSException e){
            //deal with it :)
        }
    public void shutdownGMS(){
        gms.shutdown(GMSConstants.ShutdownType.INSTANCE_SHUTDOWN)
    }
}
```

Shoal GMS Client CodeSample

```
public class GMSClient implements CallBack {
    .....
    registerWithGMS(){
        GroupManagementService gms = GMSFactory.getGMSModule(clusterName);
        //register interest in events
        gms.addActionFactory(new JoinNotificationActionFactoryImpl(this));
        gms.addActionFactory(new FailureSuspectedActionFactoryImpl(this));
        gms.addActionFactory(new FailureNotificationActionFactoryImpl(this));
        gms.addActionFactory(new FailureRecoveryActionFactoryImpl(this));
        gms.addActionFactory(new PlannedShutdownActionFactoryImpl(this));
    }

    processNotification(Signal signal){
        //process the appropriate Signal type, say FailureNotificationSignal according to client logic
    }
```

As seen above, for GMS clients, this is a Breeze to do and very simple. GMS takes on complexities of Group and Endpoint discovery, failures, etc.

Shoal GMS in GlassFish V2

- In GlassFish v2 cluster mode, Shoal GMS is used for
  - Automated delegated transaction recovery
  - Timer migrations
  - IIOP Failover Loadbalancer
  - Self Management
  - Read-only Bean's cache change notifications
  - Domain Admin Server for cluster health
  - In-memory replication component's discovery and failure detection needs.

Shoal GMS in the enterprise world

- Shoal can be used for common enterprise clustering requirements
- Some products that can benefit
  - MQ Broker Clusters
  - Directory Server Clusters
  - Compute Grid
  - Telco carrier grade app infrastructures
  - App level clustering in small scale deployments (plug in Shoal into a GF v1 instance, and apps can directly use it for their cluster needs)
  - Several others limited only by imagination and some contrarian thinking :)

GMS SPI Highlights

- Goaled to work with both JGroups and JXTA
- Extracted out of common functionalities from both the group communication technologies and GMS client requirements
- Open to other GCP implementations as suitable for a specific application
- SPI rev is in progress to make it more comprehensive and truly pluggable

GMS's Use of JXTA

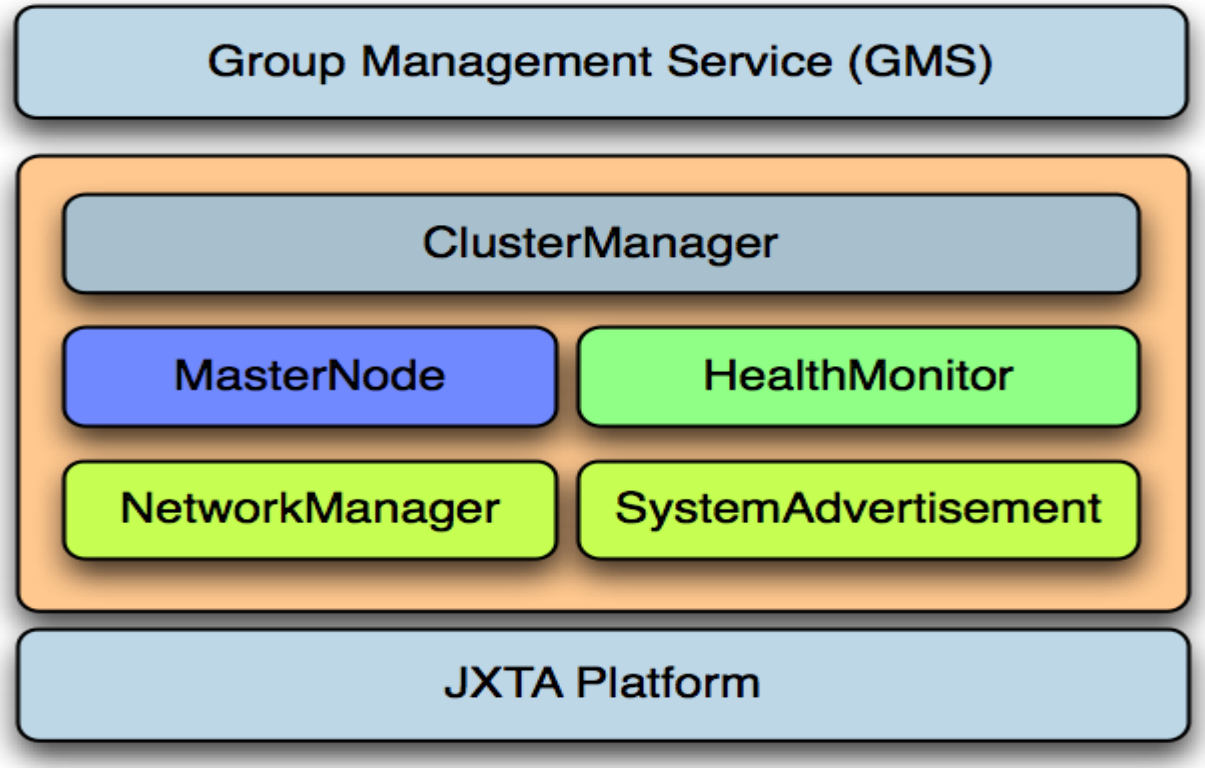
- GMS requirements
- Jxta Management – a collaborative effort between Appserver Group and JXTA (Advanced Development) Group
- Critical JXTA Platform Functionality

GMS Requirements

- At the minimum
  - Group and Membership detection
  - Failure Detection
  - Guaranteed Message delivery
  - Ordered Messaging (particularly for group membership messages)
- Of Added Use
  - Flow Control (Dynamic Sliding Window management)
  - Merging of split groups
  - Fragmentation of packets over 64K

JxtaManagement Architecture

- Shoal GMS utilizes JxtaManagement component (a JXTA based group service provider) for dynamic cluster configuration, formation, and monitoring.



JxtaManagement Architecture

- NetworkManager
  - Given instance and group name, uses a SHA-1 hash to encode the cluster GroupID, and NodeID
  - defines a set of predefined communication identifiers used for formation, monitoring and messaging.
  - Application can pass additional config parameters, such as bootstrapping addresses to facilitate cross sub-net and firewall communication.
- SystemAdvertisement
  - An extensible XML document describing system characteristics (HW/SW configuration. CPU load would be a nice extension).
  - Envisioned that this would serve at the foundation of a Grid framework.
- MasterNode
  - Lightweight protocol allowing a set of nodes to discover one another, and autonomously elect a master for the cluster.
  - Resilient to multi node collisions and employs an autonomous mechanism to avoid network chatter to resolve collisions.

Jxta Management Architecture

- ClusterView
  - Maintains an ordered view of the Cluster
- HealthMonitor
  - A lightweight protocol allowing a set of nodes to monitor the health of a cluster.
  - Relies on a tunable heart beat,
    - acted upon by MasterNode to notify the group of failures,
    - and by other members to elect a new master if the master node fails.
- ClusterManager
  - Manages lifecycle of this SPI

Critical Jxta Platform Functionality

- Membership scoping - Infrastructure NetPeerGroup provides group isolation from the world
- Rendezvous Protocol - PeerGroup and Peer locational and route tracking, and provides end point routing abstraction
- Platform provides virtualizing of PeerID to network addresses
- Platform's messaging envelope - the Message object encapsulates MessageElements allowing for separation of payload from metadata
- Secure communication channels – PKI-based public key for Unicast, shared keystore based for multicast
- NetworkConfigurator – API for programmatic configuration, configuration stays in-memory during lifetime of peer.

Current Status, Tests Run

Current Status

- Source code has been made available at Project Shoal. Download it and have fun with it :)
- GMS SPI implementation uses Jxta layer implementing Group Communication Provider SPI initial version
- Weekly review meetings with JXTA team for continuous improvement

Tests Run

- Tests covered: Various time Startup scenarios, Join tests, Shutdown tests, Failure tests, and Recovery behaviors tests
- QE continues to run test cases from their GMS suite of 40 tests with several iterations. Many tests involve timing variations as well.
- P3s are being filed as they are identified.

Plans

- Stabilize current implementation for release with GlassFish Application Server 9.1
- Involve user community to test and deploy Shoal and contribute bugs and RFEs.
- Possible Shoal Cache implementation being looked at.
- Shoal for compute grid being worked on.
- Engage within and outside Sun for adoption.
- Shoal as a driver for GlassFish adoption.