Towards Autonomic Networking Middleware

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The Autonomic Control Loop (1)
The Autonomic Control Loop (2)

- **Concept exists for a long time**
  - Borrowed from control theory, manufacturing

- **Primary focus on management logic**
  - Addresses what an Autonomic Manager does, and how
  - Standardization: Knowledge representation
  - Differentiation through M-A-P-E component logic

- **Secondary focus on manageability**
  - How a resource exposes its sensors and effectors
  - Objective: create open standards
Standards needed for Autonomic Computing

- **Solution Deployment Descriptors (W3C, new OASIS SDD Technical Committee)**
- **Common Base Event (OASIS WS-Distributed Management Technical Committee)**
- **WS-Notification (OASIS)**
- **WS-Manageability (OASIS WS-Distributed Management Technical Committee)**
- **Managed Resource**

**Sensors** → **Monitor** → **Knowledge** → **Plan** → **Execute** → **Effectors**

- **WS-Agreement** (GGF Grid Resource Allocation Agreement Protocol Workgroup)
- **WS-BPEL** (OASIS WSBPEL Technical Committee)
- **WS-Policy** (OASIS)
- **Distributed Management Task Force (DMTF) CIM**
- **Managed Resource**
- **Sensors** → **Effectors**

- **Knowledge**
- **Plan**
- **Execute**
What does “autonomic” actually mean?

- “Smart” management system executes the MAPE-K loop
  - Interacts with “dumb” managed resources
  - If sub-optimal, configures them so that global optimum is achieved
  - E.g., OSI Network Management: Manager/Agent paradigm
  - How systems management is done today

- Every individual system runs its own MAPE-K loop
  - and, somehow, optimal behavior of the overall system emerges
  - E.g., Routing algorithms, as implemented in OSPF, BGP
  - Smart resources, no management system needed

These are 2 fundamentally different viewpoints
…and these 2 Viewpoints have been articulated long ago

- “What we see are merely reflections of perfect archetypes” (Plato)
  - Basically, the world is in equilibrium
  - If a system gets pushed outside of the equilibrium, push it back again
- “The world is in a constant state of flux” (Heraclitus)
  - The world is in a process of flow and change
  - Systems are interacting in a variety of combinations
- Variations of these viewpoints reflected in middleware paradigms
  - Synchronous vs. asynchronous communication (RPC vs. messaging)
  - Manager/Agent model vs. peer-to-peer interactions
  - Workflows vs. business objects
Solving the right problems

- **Scientific community’s main focus areas:**
  - Optimization techniques
  - (Mathematical) system modeling and design
  - Rigorous evaluation of results through experiments
  - Achieving automation

- **Major headaches in practical IT service management:**
  - Availability and problem determination
  - Dealing with human error
    - More than 50% of service outages due to misconfiguration
  - Repeatable procedures for changing systems
    - More than 50% of service outages happen during maintenance windows
  - Labor Costs
  - “Good enough” solutions
  - Reluctance to immediately implement automation, based on past negative experience

**Plenty of opportunities for the scientific community!**

### Data Center Activities

<table>
<thead>
<tr>
<th>Priority</th>
<th>Activity</th>
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<td>Priority</td>
<td>Resolve Problems</td>
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<td></td>
<td>Configure/Install</td>
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<td>Collect change request and gain approval</td>
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<td>Support SW (e.g. OS files, processes)</td>
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<td></td>
<td>Perform customer-driven changes</td>
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<td>Define Requirements / Plan</td>
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<td>Upgrade</td>
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<td>Apply patches</td>
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<td>Analyze and maintain user requirements</td>
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<td>Manage system availability, capacity</td>
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<td>Test</td>
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<td>Maintain Policy, processes, procedures</td>
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<td>Support Hardware (e.g. server, disks)</td>
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<td>Perform internal-driven changes</td>
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<td>Audit Compliance</td>
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<td>Perform User Mgmt and housekeeping</td>
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<td>Maintain Configuration info</td>
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<td>Perform health check</td>
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<td>Handle special projects/requests</td>
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Research Challenges in Networking Middleware

- **Codify best practices for running IT systems**
  - IT Process Management, Service Flows

- **Service Level Agreements**
  - Express cost and profit functions
  - Multiple layers of SLAs
  - Automated reconciliation of external with internal goals (aka Policies)

- **Determining the location of a managed resource**
  - Often, servers in a data center are in 192.168 subnets
  - Legal implications on where (corporate) data is stored

- **(Security and Trust)**
  - Discrepancy between attributed importance and business opportunity
The need for best practices

- **Development organizations:**
  - Management costs viewed as support, not development costs
    - Core business: adding new functionality to products
    - Not: Making products easier to administer
  - Fortunately, this begins to change

- **IT organizations:**
  - Estimating the impact of a change is extremely difficult
  - Results in:
    - Setup of dedicated staging environment
    - Manually try out what works best (or at all)
    - Create *IT run books* detailing the procedures
  - Huge costs (equipment, personnel)
  - Takes up to 90 days for complex changes
  - Still no guarantee that the procedure will really work in production
  - Every IT organization reinvents the wheel
Planning to Implement Service Management

Service Management

Service Delivery

Service Support

Support Management

Software Asset Management

Application Management

IT Infrastructure Management

The Business Perspective

The Technology

Codifying Best Practices: IT Infrastructure Library (ITIL)
Customer Rankings of ITIL Processes

Most Critical Processes

- Problem Mgt: 57% Extremely Familiar w ITIL, 54% Extremely Familiar / Familiar
- Change Mgt: 57% Extremely Familiar w ITIL, 58% Extremely Familiar / Familiar
- Config Mgt: 71% Extremely Familiar w ITIL, 33% Extremely Familiar / Familiar
- Availability Mgt: 29% Extremely Familiar w ITIL, 33% Extremely Familiar / Familiar
- Incident Mgt: 57% Extremely Familiar w ITIL, 67% Extremely Familiar / Familiar
- Security Mgt: 14% Extremely Familiar w ITIL
- IT Continuity Mgt: 29% Extremely Familiar w ITIL
- Release Mgt: 13% Extremely Familiar w ITIL
- Service Mgt: 8% Extremely Familiar w ITIL
- Capacity Mgt: 13% Extremely Familiar w ITIL
- Financial Mgt: 0% Extremely Familiar w ITIL
- Other: 4% Extremely Familiar w ITIL
- None: 0% Extremely Familiar w ITIL

A4. For which three service management processes from the list below is compliance with ITIL most critical to your organization?
ITIL Service Management Processes

**Service Support**
- Incident
- Problem
- Change
- Release

**Configuration**

**Service Level**
- Financial
- Availability
- Capacity
- Service Continuity

**Service Delivery**

**Problem:** These Processes are described in textual form

Need to create models that can be interpreted by workflow systems
Relationships between ITIL Service Support Processes

- Accept and Classify Change Requests
- Assess Impact of Changes
- Coordinate Change Implementation
- Review and Close Change Request
- Monitor and Report Change Management
- Distribute and Install Changes
- Report Configuration Status
- Verify and Audit Configuration Items
- Identify and Control Configuration Items
- Forward Schedule of Change
- Plan Release
- Design Release
- Build Release
- Test and Accept Release
- Plan Rollout
- Communicate, Prepare, Train for Release
- Distribute and Install Release
- Release Management Report

Configuration Management Database (CMDB)
Architecture and Inputs of a Change Management System

Stakeholder | Requirement | Service Provider
---|---|---
Customer | Request for Change | Administrator
Developer | Deployment Descriptor | Policies and Best Practices
Customer | Service Level Agreement | 

Change Management System

- Workflow Generator
- Workflow
- Scheduler
- Workflow Repository
- Forward Schedule of Change
- Status
- Status
- Provisioning System
- Data Center Resources
Service Level Agreements

- **What are the key performance indicators (KPIs)?**
  - Availability, response time, throughput, bandwidth...

- **How are they defined?**
  - Need to break down KPIs into measurable parameters

- **Who monitors compliance?**
  - Service Provider
  - 3rd party Measurement Services, e.g. Keynote

- **What are the maintenance intervals?**
  - Different time periods have different cost/profit functions

- **How is all this information put together?**
  - SLA templates are too inflexible
  - SLA languages, e.g. WS-Agreement

- **Is automated SLA negotiation a priority?**
Are SLAs hard to specify? (e.g., WS-Agreement)

- **Time intervals**
- Costs and profits are specified the same way
- Additional penalties if not resolved within a certain time period
- Additional bonus for continuous uptime

- **5 $ per Minute**

WSAG Service Properties:
- wsag:ServiceProperties
  - wsag:ServiceName=ServerResourceInCustomerApplication
  - wsag:GuaranteeTerm
    - wsag:ServiceScope From_900am_To_500pm
    - wsag:ServiceScope From_5pm_to_9am
    - wsag:ServiceScope In_every_Minute
    - wsag:ServiceScope
  - wsag:BusinessValueList
    - Additional penalties if not resolved within a certain time period
    - Additional bonus for continuous uptime
  - wsag:Penalty
    - wsag:AssessmentInterval
      - wsag:TimeInterv... PTIM
      - wsag:ValueUnit USD
      - wsag:ValueExpr 5.00
    - wsag:AssessmentInterval
      - wsag:TimeInterv... PTIM
      - wsag:ValueUnit USD
      - wsag:ValueExpr 50.00
    - wsag:AssessmentInterval
      - wsag:TimeInterv... PTIM
      - wsag:ValueUnit USD
      - wsag:ValueExpr 500.00
    - wsag:AssessmentInterval
      - wsag:TimeInterv... PTIM
      - wsag:ValueUnit USD
      - wsag:ValueExpr 5000.00
  - wsag:Reward
    - wsag:AssessmentInterval
      - wsag:TimeInterv... PTIM
      - wsag:ValueUnit USD
      - wsag:ValueExpr 10
    - wsag:AssessmentInterval
      - wsag:TimeInterv... PTIM
      - wsag:ValueUnit USD
      - wsag:ValueExpr 100

Costs and profits are specified the same way.
Crafting SLAs is an Art!

- **If Servers become overloaded, which Customer will be starved out?**
  - Classify customers according to revenue
  - SLA violation may not be due to technical failure, but result of business decision

- **Customer A signs an SLA for 99% availability over a year**
  - Service provider is able to keep the site up throughout the year
  - Busy Christmas shopping season stretches provider’s resources
  - What will the service provider do?
    - Leave Customer A’s Internet storefront untouched
    - Shut down Customer A’s storefront for 3.5 days in a row?
      - Without paying any penalty as he is still within the allowable range of downtime
    - Ask customer for additional money to keep his site up and running

- **What will an automated Service Provisioning System do?**
Autonomic Networking Middleware: Takeaway Points

- **Major progress in core technologies for Networking Middleware**
  - Self-* technologies, context and location awareness, P2P systems
  - However, these core technologies seem isolated

- **Need to put the parts together, think in a bigger context**
  - Address the major pain points of real-life environments
  - Study the problems that yield the most “bang for the buck“ first

- **Some focus areas:**
  - IT Processes as a way to codify best practices
  - Service Level Agreements are prerequisite for automation

- **Automation will only happen gradually over time**
  - Deal with human error, e.g., in system configuration

- **Some of this may sound like “soft topics”**
  - However, under the covers, there is plenty of “rigorous science”
Q & A