Architecting Self-Managing Distributed Systems
The DIME Computing Model & the Manageability of Computed and the Computer

Application of O-Machine Design to Architect Self-Managing Distributed Databases

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The Complexity of Manageability in Distributed Systems

Cloud is a pool of on-demand managed resources

Turing Machines do not include manageability and assume infinite resource pool
“The key property of general-purpose computer is that they are general purpose. We can use them to deterministically model any physical system, of which they are not themselves a part, to an arbitrary degree of accuracy.

Their logical limits arise when we try to get them to model a part of the world that includes themselves.”


Manageability is in the architecture ...

A non-functional requirement is a requirement that specifies criteria that can be used to judge the operation of a system, rather than specific behaviors. This should be contrasted with functional requirements that define specific behavior or functions.

The plan for implementing functional requirements is detailed in the system design. *(The Computed)*

The plan for implementing non-functional requirements is detailed in the system architecture. These requirements include availability, reliability, performance, security, scalability and efficiency at run-time. *(The Computer)*
What is the DIME Network Architecture (DNA)

DIME (distributed intelligent managed element) is a form of computing that introduces manageability using Oracle* design, Oracle networks and process control by Oracles.

It configures the computer with appropriate resources, monitors its vital signs and acts to optimize resources based on a blueprints of descriptions of the computers and the computed.

It manages the Life-cycle quality of computation, including mobility, self-repair, replication, and security.

* Following Turing’s comments in his thesis borrowing the concept of the Oracle of Delphi.
Oracle Design & Super Recursive Computing

- DIME is the prime instrument for configuring, monitoring and controlling the computation with appropriate resources
- Managed Computations of DIMEs are composed to create groups
- Groups are used to compose higher level computations and a group is managed by a group oracle
- Down-stream or lower level computations are managed by configuring, monitoring and controlling them using an oracle network with global view of all relevant computations at hand

The Oracle machine interrupts the instruction cycle to provide monitoring and control of the evolution of the Turing Machine execution."
The Oracle Machine Design – The Computer & the Computed

• Every computed is configured, monitored and managed to execute in best execution venue (BEV) using an Oracle
• Oracle is more able than the group it manages
• Able to influence the computation based on its “blueprint” of description or specification
• Provides the ability to infuse cognition (self-* properties) into computing
• Allows Super Recursive Computing at the group level

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What is DIME Network Architecture

**Self-Awareness:** Application is embedded along with parallel resource monitors and configuration Managers to optimize resources

**Self-Reasoning:** Signaling overlay network allows service transaction policy management and distributed reasoning at run-time

**Self-Control:** File/device Read/Write control based on local policies driven by global policies and soft-switch for I/O redirection at run-time

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The evolution of cloud computing

Unification of the computer and the computed

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Scaling with number of compute elements

System Resiliency

Conventional computing

Cloud Computing

Automation of Administration & point of diminishing returns

Complexity cliff

Beyond Cloud Computing:

Cognitive Cloud: Hyper-scale, resiliency & efficiency of computation

Layers of resilient infrastructure management Silos

Model of part of a world that includes the Computer and the computed seamlessly

Conventional computing

Layers of rigid infrastructure management silos

Efficiency
DIME Networked Application Group Example

DIME Network Blueprint

Non-functional Requirements
Policies
Workflow Managers

DIME

Process Dynamics
Runtime

DIME
Libraries
OS native Applications

DIME
DB

DIME
Reader

DIME
Writer

DIME
Deamon
Docker LXC/LXD

Distributed Cognitive DIME Platform

OS

Managed Service Network

Non-functional Requirements fulfillment
Wide Area Application Managers & Policies

Application Area Network Managers
Runtime

App
DB
App
Applications
App
DB
App

IP-1
IP-2

Distributed Computing Cluster Nodes

Distributed Intelligent Infrastructure Control Plane

Logical Distributed Computing Cluster Network

Any Public Cloud
Infrastructure Virtualized or Not
Physical Hardware

Managed Distributed Infrastructure

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Video – Replicate an existing App

1. Discover & Migrate

Cisco Cluster 1

2. Replicate

Cisco Cluster 1
Video – DB Migration

Live-Migrate & Synchronize DB across Multiple Clouds

Cisco Cluster 1

Cisco Cluster 2

AWS Cluster

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Transactions Writer
Please, select the number of transactions per minute:

20 tr/min

by the C³DNA Hypercloud Application Platform

C³DNA Inc. - www.c3dna.com
Transactions Reader

List of the latest 10 transactions:

<table>
<thead>
<tr>
<th>Tr#</th>
<th>Writer</th>
<th>Database</th>
<th>Timestamp</th>
</tr>
</thead>
</table>

by the C3DNA Hypercloud Application Platform

Display transactions in Real time (transaction contains application and database IP addresses when the transaction is created wherever they are)
MySQL IP address change with no transaction loss
### MySQL IP address change with no transaction loss

#### Transactions Reader

List of the latest 10 transactions:

<table>
<thead>
<tr>
<th>Tr#</th>
<th>Writer IP</th>
<th>Database IP</th>
<th>Timestamp</th>
</tr>
</thead>
<tbody>
<tr>
<td>35</td>
<td>173.39.214.98</td>
<td>54.187.140.40</td>
<td>2015-05-21 17:33:00</td>
</tr>
</tbody>
</table>
Potential Impact of our Solution on Stakeholders

**Line-of-Business**
- Assurance of Service Levels, QoS
- End-to-end visibility and control
- Precise resource accounting
- Regulatory Compliance

**Developers**
- Ability to use the latest, coolest development tools
- Service Composability with QoS
- Service scalability, reliability and security without worrying about architecture or infrastructure
- Converged DevOps for dev/test/deploy agility
- End-to-end visibility across the stack for debugging

**Enterprise IT**
- Policy-driven visibility and control for developer workloads
- Security and Regulatory compliance
- No Cloud vendor lock-in
- Eliminate VM Taxes!
Application 1

Requirement:
• Easy onboarding of existing and new applications
• High degree of Reliability and Resilience
• Application availability & service level assurance across clouds

DIME network Solution
• One-Click onboarding of legacy and new applications
• Hardening of Intercloud OpenStack infrastructure
• Apply policies dynamically to change application deployment behavior
• No dependence on underlying infrastructure.

Intercloud

Beta in progress at two of their data centers in Texas and Virginia

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Application 2

Requirements:
Service Orchestration for high availability, performance optimization and security

DIME Network Solution
• One-Click infrastructure provisioning via real time interface.
• One-Click onboarding of legacy and new applications
• Apply policies dynamically to change application deployment behavior
• One-Click inter/intra cloud service orchestration
• Offer DIME Network service orchestration to CenturyLink cloud customers through their Blueprint offering using their self-service portal
  • On-board applications to CenturyLink Cloud from other clouds and datacenters without disruption to their services
  • Provide inter-cloud and intra-cloud application live-migration, self-repair, auto-scaling and self-protection
  • Multi-datacenter/Cloud HA/DR without infrastructure based backup and recovery tools – multi-database synchronization, data consistency and live-migration based on RPO & RTO
  • Interoperable shared services between private and public Datacenters

Beta in progress at their data centers with Site to site VPN between CenturyLink cloud and other datacenters
Co-design Partner - Sabre Holdings

Requirement
- Modernizing legacy applications for cloud scaling and resilience
- Enable proactive monitoring and control of web-scale applications and consistent Dev-Ops process from build and test to operate – Tomcat, MySQL, Apache, Passenger etc.

DIME Network Solution:
- Bring Cloud scaling and resilience to legacy applications
- Policy-based Multi-master HA/DR without re-architecting of MySQL or change database
- Enterprise-wide standardization of application-level monitoring and control

Product capability demonstrated by successfully migrating their TripCase app.

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"It's very likely that on the basis of philosophy that every error has to be caught, explained, and corrected, a system of the complexity of the living organism would not run for a millisecond."


The DIME Network Architecture puts safety and survival of application/service first allows the application to self-scale, self-migrate and allows sectionalizing, isolation, diagnosis and fixing of errors at leisure.