



# CEREUS: CYBERINFRASTRUCTURE ENVIRONMENTS FOR RESOURCE EXCHANGE AND UTILITY SERVICES

DUKE UNIVERSITY, DEPARTMENT OF COMPUTER SCIENCE

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**Objective: manage shared cyber infrastructure as an on-demand utility in which computing resources are as easy to access as electricity, with access policies that are fair, flexible, effective, and robust.**

## Goals and Rationale

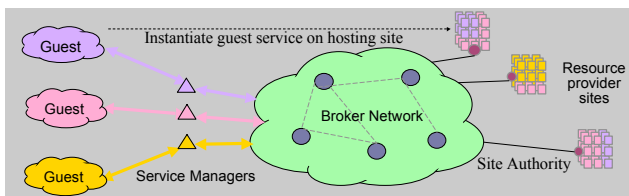
- Manage server and storage infrastructure as a shared resource, like the rest of the network.
  - Distributed investment costs, economies of scale
  - Distributed risk of load surges and resource failures
  - Harness surplus resources, multiplex bursty demand
- Protect shareholders from the risks of resource sharing.
  - Contractual performance assurances (leases)
  - Secure isolation from competing users (or attackers)
  - User control over configuration and access
- Adapt to dynamic conditions.
  - Continuous, reliable service: reconfigure around failures, load services, and other conditions (e.g., thermal hot spots).
  - Fast response with low operational cost: self-managing or "autonomic" system

## Cluster-on-Demand (COD)

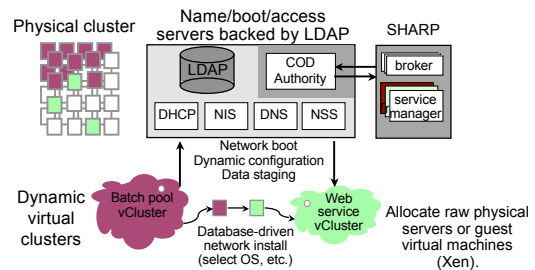
- Example: **Cluster-on-Demand (COD)** is a SHARP authority service for LDAP-administered cluster sites.
  - NSF National Middleware Infrastructure (NMI) funded project
  - Duke/CSEM deployment in progress, seeded by IBM
- COD guests may run within isolated **virtual clusters**.
  - Supports virtual machines (e.g., Xen, VMware).
- Default COD service manager is a web/email user interface.
  - Pluggable automated service managers for feedback control, e.g., meet objectives in Service Level Agreements (SLAs).
  - Batch schedulers for computational clusters (e.g., Globus GRAM with PBS/SGE batch job management).
- Flexible and reliable configuration management with user-specified XML event handlers (based on Apache Ant).

## Providers, Guests, and Brokers

- Architecture and player roles defined by **SHARP** framework
  - Secure Highly Available Resource Peering (SOAP/XML)
- Resource providers are cluster/storage sites (e.g., a cell of a data center), each controlled by a **site authority** service.
- Resource consumers are application services that run as guests on the resources of hosting sites.
  - E.g., hosted Web services or Grid/PlanetLab services
- Each guest is controlled by a **service manager**.
  - Negotiates for resources on behalf of the guest.
  - Monitors execution of the guest, responds to events.
- **Brokers** match consumers and suppliers, arbitrate demands.
  - Resource discovery and resource management



- Long-term research: policy for brokers and service managers



## A Leasing Market for Cyberinfrastructure

- **Research focus:** market-based control for resource access based on cash, credits, or a virtual currency.
  - Balance resource supply and demand
  - Allocate resources to their "highest and best use"
- Self-organizing, self-optimizing emergent global behavior
  - *Sustainability:* create incentives for sites to contribute resources
  - *Arbitration:* create incentives to schedule usage under constraint
- Brokers conduct regular auctions for resource contracts.
  - Service managers bid from a currency budget.
  - Incentive-compatible auction protocols with posted price signals.
  - Brokers trade resource rights: resources diffuse through the network of brokers by following the price gradients.

## Resource Contracts: Leases

- SHARP protocol uses asymmetric cryptography as basis for secure and **accountable** resource lease contracts.
  - Digitally signed XML assertions (future: SAML)

Shorter leases have higher overhead, but are more agile with changing demand.

Longer leases give stronger assurance of stable resource control by the holder.

```

</lease>
<issuer> Site A's public key </issuer>
<signed_part>
<holder> SM's public key </holder>
<rset> 20 type 4 servers </rset>
<start> Monday 12:01 AM </start>
<end> Tuesday 11:59 PM </end>
<sn> unique ID at Site A </sn>
</signed_part>
<signature> A's signature </signature>
</lease>

```

## Accountable Auctions and Virtual Currency

- **Accountable cooperation:** participants are community members securely bound to identities and subject to sanction.
  - All SOAP/XML message exchanges are digitally signed and timestamped: actions are tamper-evident and non-repudiable.
  - Untrusted auditors inspect signed action records to detect lying, cheating, or stealing, and prove it to a third party.
- **Self-recharging virtual currency**
  - Budgets expire/replenish automatically: limits instability due to hoarding and predatory behavior in money economies.
  - Currency is issued by a central bank, but participants trade directly; received currency is redeemable at the bank.
  - Participants are accountable for their currency management.