GENICLOUD: AN ARCHITECTURE FOR THE INTERCLOUD

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WHY PLANETLAB AND THE CLOUD?

- Strengths of (existing) PlanetLabFacilities
  - Broad global reach
  - Large (aggregate) bandwidth and low latency to everywhere
  - Point of presence everywhere on earth
- Weaknesses of PlanetLab facilities
  - Not much computation available anywhere
- Strengths of the Cloud
  - Large chunks of computation available
- Weaknesses of the cloud
  - Bandwidth limited to a few centers
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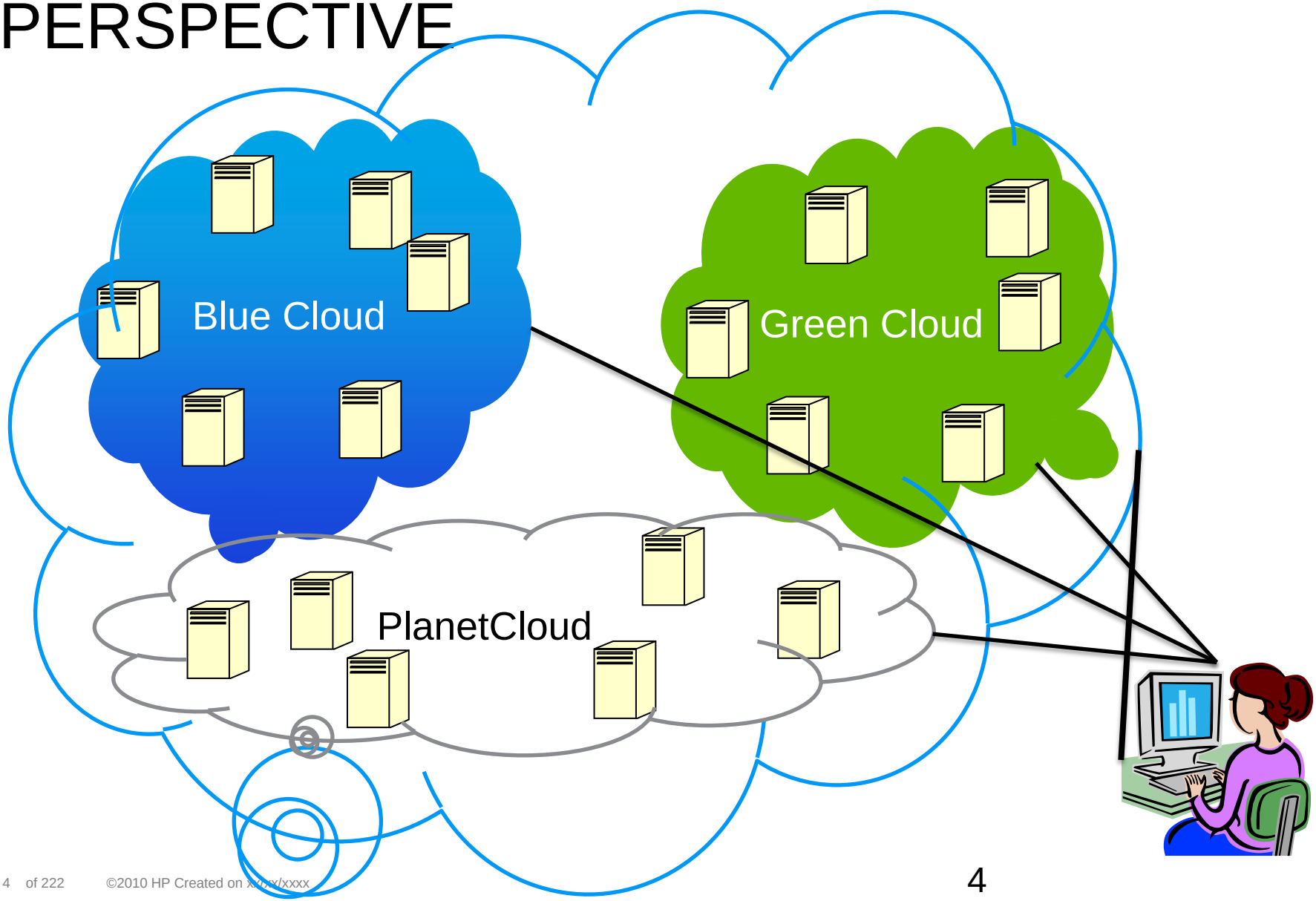
MOTIVATION: THE INTERCLOUD

- Internet: set of standards and protocols which permit interconnection of independently-administered networks
  - Network of networks
- Intercloud: Set of standards and protocols which permit interconnection of independently administered clouds
  - Term due to Greg Papadopoulos
  - Defining infrastructure of 2010's and beyond
- Question: What will the Intercloud look like? What makes it an intercloud (as opposed to a Cloud)?

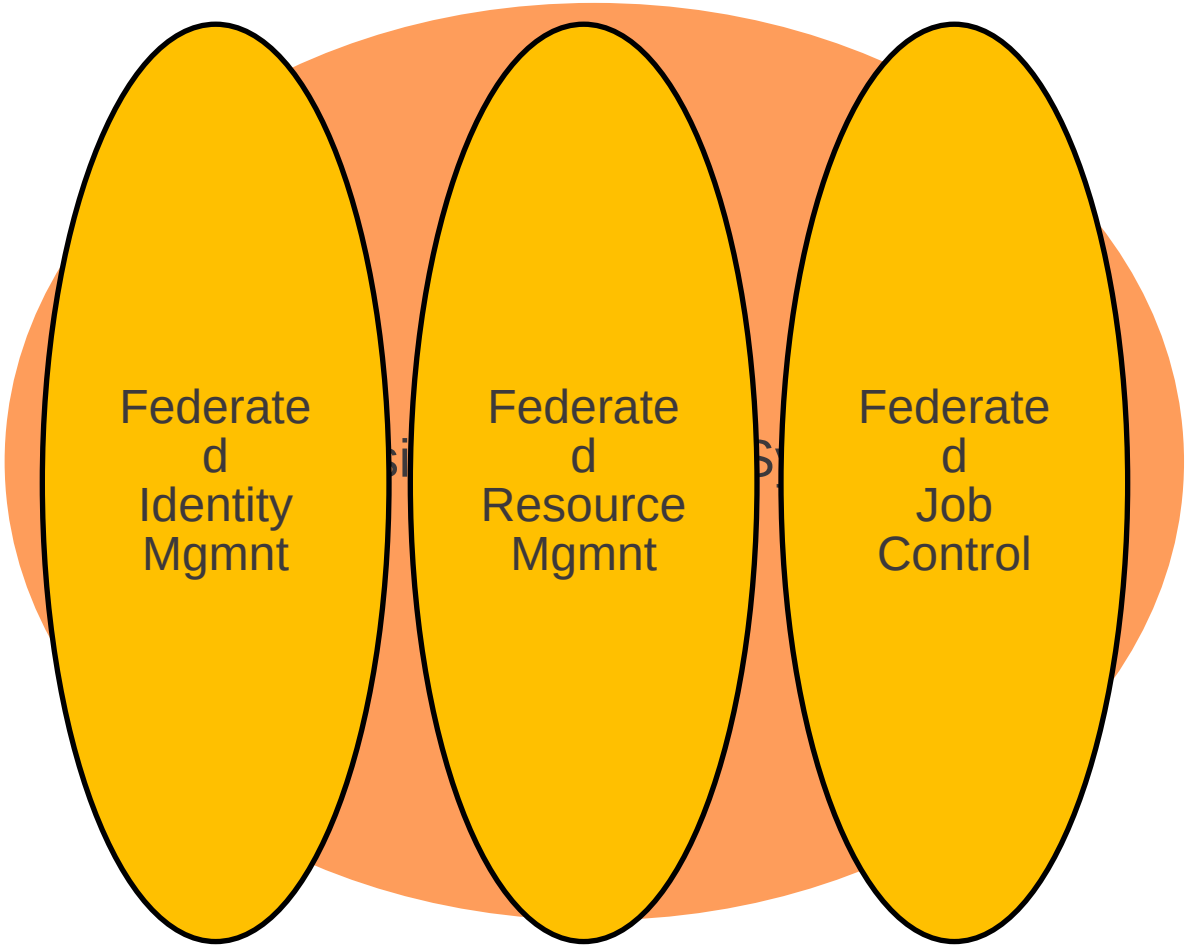
INTERCLOUD FROM A DEVELOPER'S PERSPECTIVE



REALIZING THE INTERCLOUD FROM A DEVELOPER'S PERSPECTIVE

- Key question: what are the *minimal* set of constructs/principles required to permit this interconnection?
- This really amounts to a set of agreements between Blue Cloud, Green Cloud, PlanetCloud
- Note that *any* agreement is *very* hard
  - BlueCloud, GreenCloud, PlanetCloud operate in different environments, different constraints
  - Even absent "walled garden" incentives, getting deep agreement is very hard
  - Ex: US law treats clusters as "munitions", restricts access to persons of various nationalities (folklore, haven't been able to nail this down)
- So…what do we really need?
- Testbed: OpenCirrus, OpenCloud, and PlanetLab
  - Three+ separate domains, two different slice managers,

FEDERATION



KEY ASSUMPTION

- Each facility implements Slice-Based Facility Interface
- GENI standard for control frameworks
- Standard, unified means of allocating
  - Virtual machines at each layer of the stack (“slivers”)
  - Networks/sets of virtual machines (“slices”)
- Already supported by PlanetLab, ORCA
- Now supported by Eucalyptus (our contribution)
- Should be easy to port to Nimbus, etc

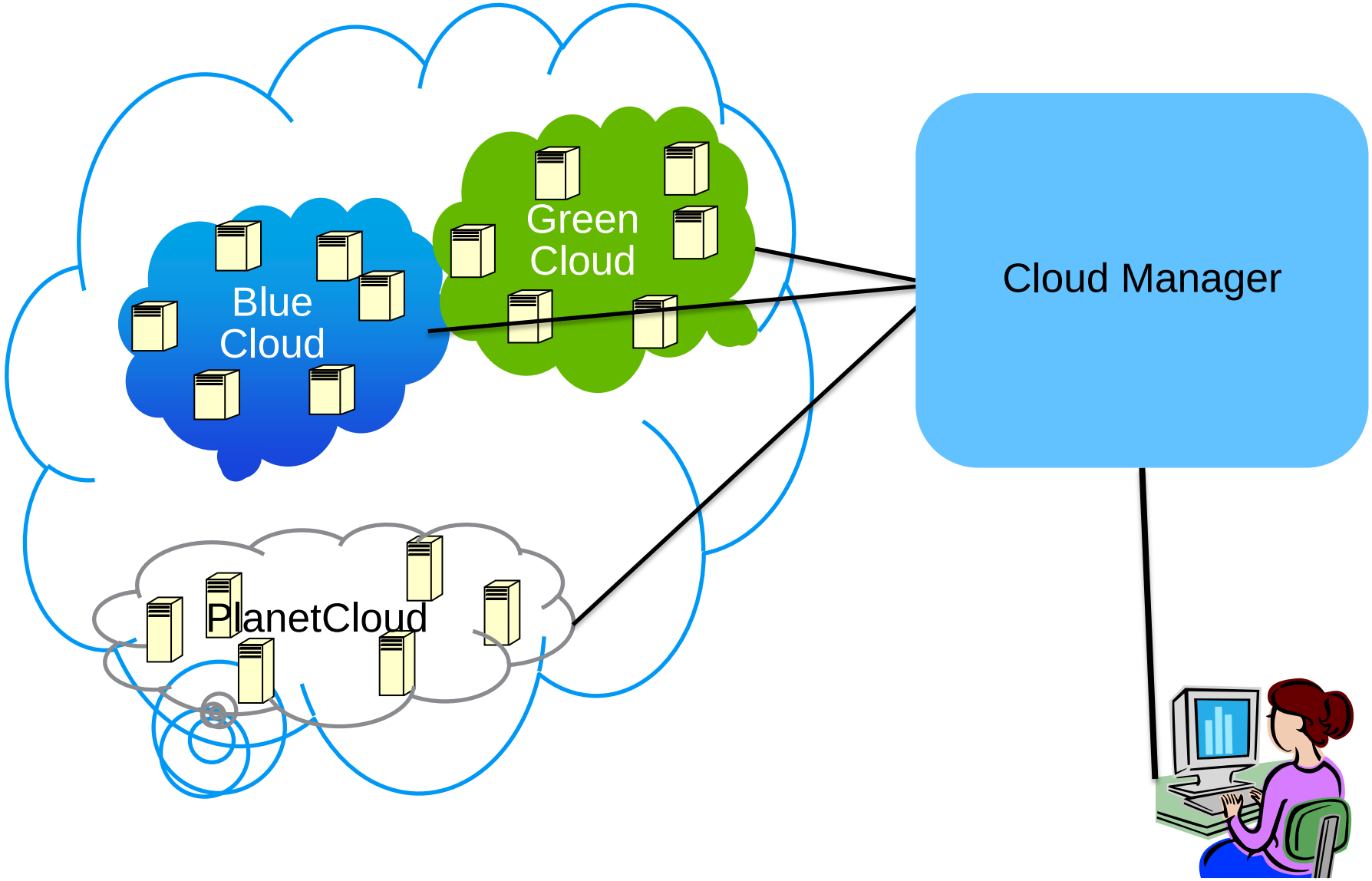
WHAT WE NEED, WHAT WE DON'T

- What we need
  - Method of creating slices on clouds and distributed infrastructures
  - Method of communicating between clouds and distributed infrastructures
  - Method of interslice communication between clouds
- What we don't
  - Single sign-on!
  - Single AUP
  - Single resource allocation policy or procedure
  - Unified security policy
- Principle of Minimal *Agreement*
  - What is the minimum set of standards we can agree on to make this happen?

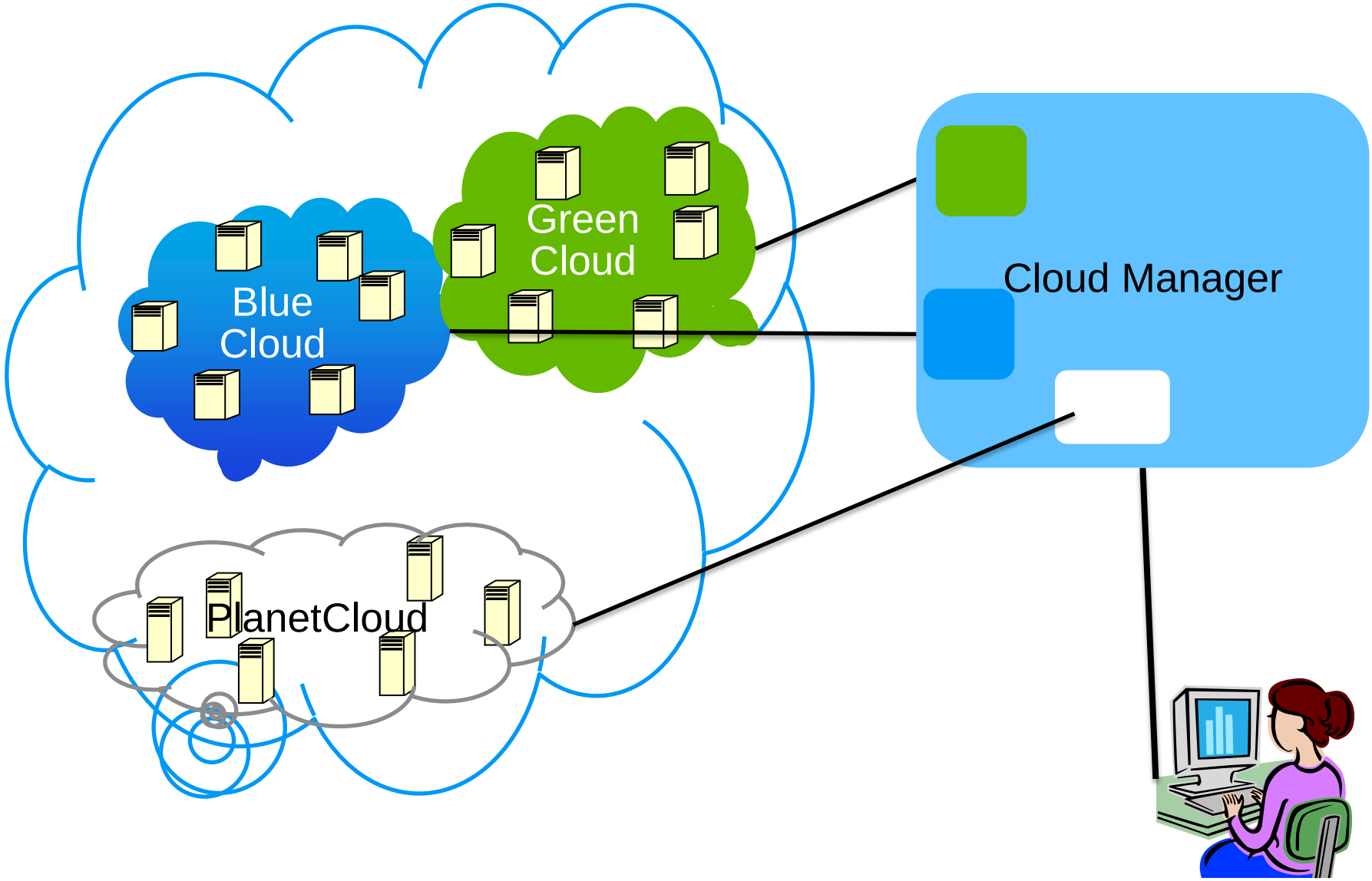
FIRST LAW OF NETWORKING

- Every problem can be solved with one more proxy
- In this case: need a *Cloud Manager*
  - User-appointed delegate to make the Intercloud look like a single Cloud
- Key:
  - Each individual cloud oblivious to the existence of the other clouds
- Analogy to proxies
  - Proxies bridge discontinuities on the Internet
  - Cloud Managers bridge discontinuities in the Intercloud (naming, user IDs, AUPs, resource allocation…)

ROLE OF THE CLOUD MANAGER



CLOUD MANAGER: PLUG-IN ADAPTERS



GENICloud Architecture

Aggregate Manager (PLC)

Slice Manager

User-facing Cloud Proxy With Distributed Rate Limits

Node Manager Sliver

Aggregate Manager

Front End

Node

Node

Node

Eucalyptus Cluster 1

Aggregate Manager

Front End

Node

Node

Node

Eucalyptus Cluster 2

WHAT DO WE NEED FROM THE CLOUDS

- Building Blocks
  - Eucalyptus: Open-source clone of EC-2
  - Widespread developer mindshare (easy to use, familiar)
- What we want: Slice Facility Architecture
  - Means of creating/allocating slices
  - Authorization by ssh key (GID)
  - Delegation primitive
  - Explicit costs/resource allocation primitives
    - Need to be able to control costs for the developer

CONCRETE ACTION

- *Every federate must support SFA API!*
  - Brought up SFA under Eucalyptus (Marco and Andy)
- Still TBD
  - Interconnect networking primitives
    - Certainly need DNS-level support
    - What else do we need?

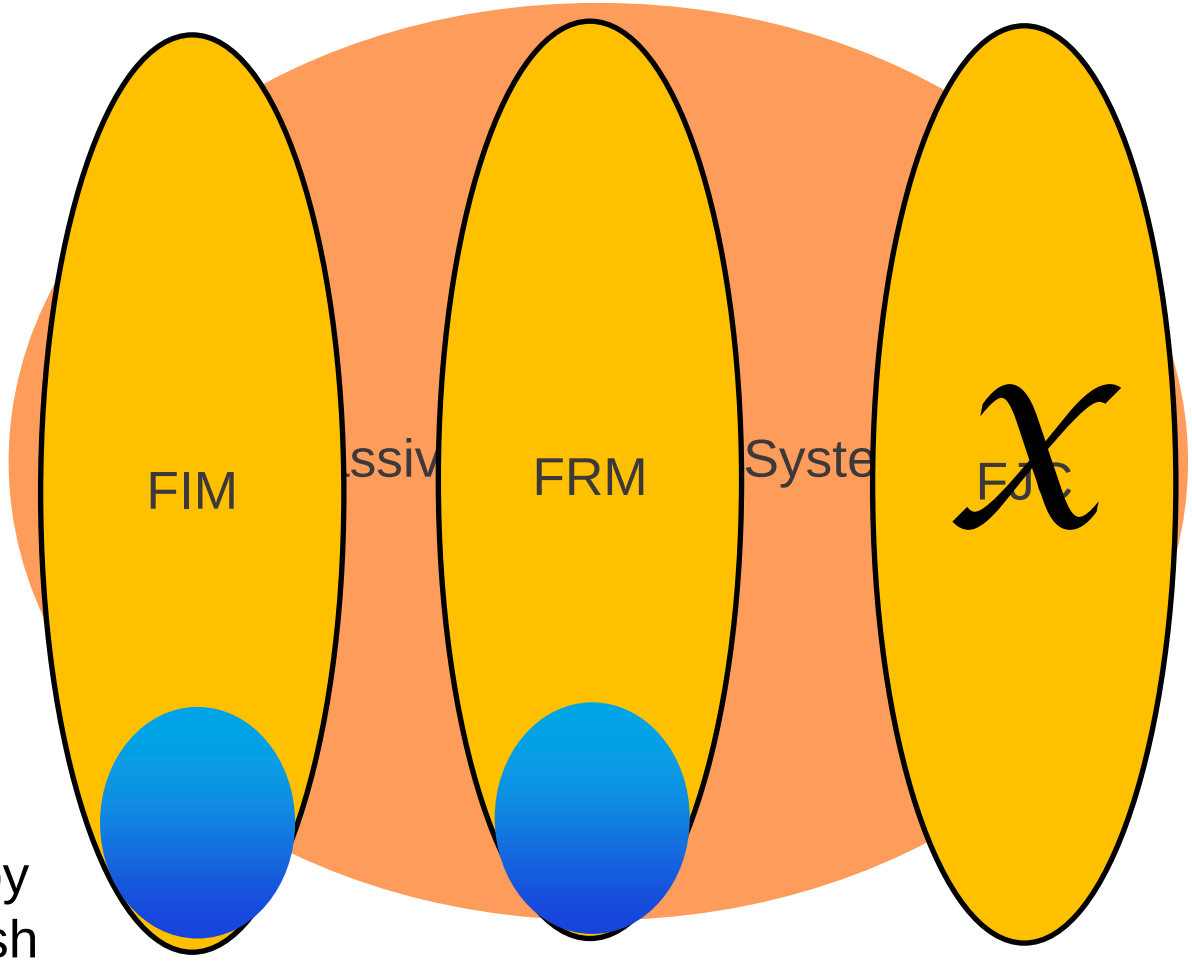
PERMISSION AND DELEGATION

- Basic protocol
  - User creates account on individual clouds
  - Appoints Cloud manager as his delegate
  - Delegates have restricted privileges
    - Create, instantiate slices
    - Upload images to slices
    - Execute jobs on slices
    - Cannot subdelegate
- Permissions
  - Done by key pair
  - Goal: User doesn’t know delegate’s private key
  - Delegate doesn’t know user’s private key
  - Delegate’s key used for no other purpose (easy revocation)

RESOURCE ALLOCATION

- At a high level, simply a uniform specification for resources and prices
  - RSPEC should work just fine
  - Need to add storage primitive (Elliot Jaffe)
- No global policy mechanisms
  - Up to me to make my own deal with each cloud
  - Cloud Manager simply spends for me to get my stuff done
- Cooperation between Green and Blue and Planet…
  - Fine, but Not My Problem.
- Acquiring resources…
  - This stuff usually works…

FEDERATION



Unified *form* of identity (by choice, ssh key)

RSPEC

IS THIS THE END OF THE ROAD?

- Of course not
- But Blue/Green/Planet Federation at a facility level will be a *lot* easier after they see what users actually do…
- History of BGP
  - EGP version 1 (RFC 827, 1982)
  - Full specification (RFC 904, 1984)
  - Use on the NSFNet Backbone (RFC 1092, 1093, 1989)
  - BGP Experimental Specification (RFC 1105, 1989)
  - Proposed standard (RFC 1163, 1990)
  - BGP-3 (RFC 1267, 1991)
  - BGP-4 (RFC 1771, 1995)
  - 20 drafts later – current BGP, BGP4, (RFC 4271, 2006)
- We’re closer to RFC 827 than RFC 4271…

NETWORK STITCHING

- Question open for debate: what should we do here?
- Tussle: deep networking capabilities vs demands on the infrastructures.
- Options:
  - None at all (PlanetLab)
  - DNS Level (no use case for layer 2 or 3) (naming)
  - Layer 3 VLANs
  - VLANs modulated by OpenFlow switches

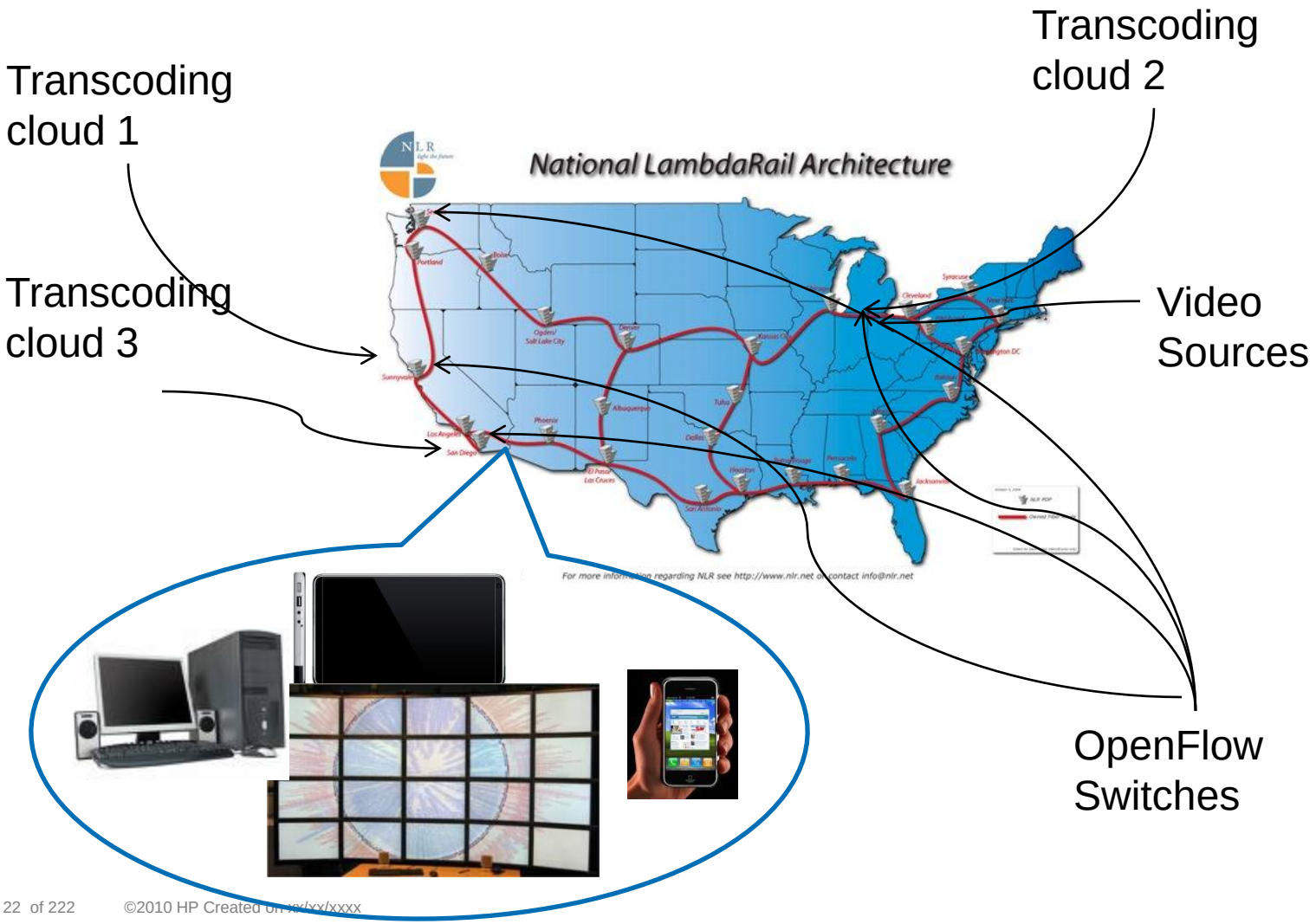
ARE CLOUD MANAGERS GOOD FOR EVERYTHING?

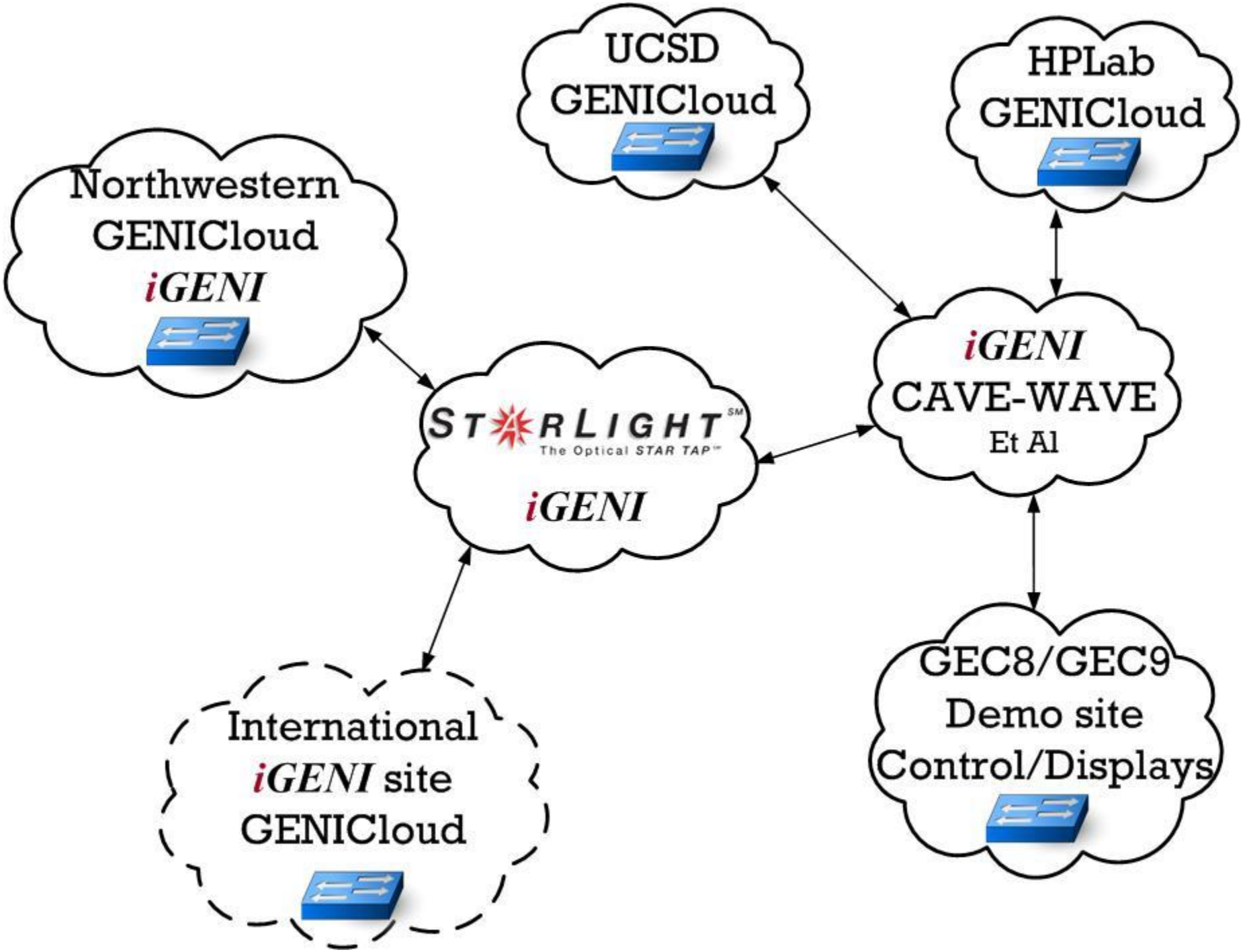
- NO! Need some minimal size of Cloud
  - Else transactions costs kill you
  - User needs to make individual deal with Cloud provider, hand delegation to Cloud Manager
  - Could never have worked for PlanetLab…

DEMO/PROOF POINT

- Build Cloud Manager and interconnect OpenCloud, OpenCirrus, PlanetLab
- First step: Eucalyptus supporting Slice-Based Facility Architecture
- Second step: Use it to support federated application
  - GEC-8
  - Transcoding cloud service running at UCSD, Northwestern, OpenCirrus
  - Service provided by Ericsson (thanks to James Kempf)

GENERAL ARCHITECTURAL PICTURE

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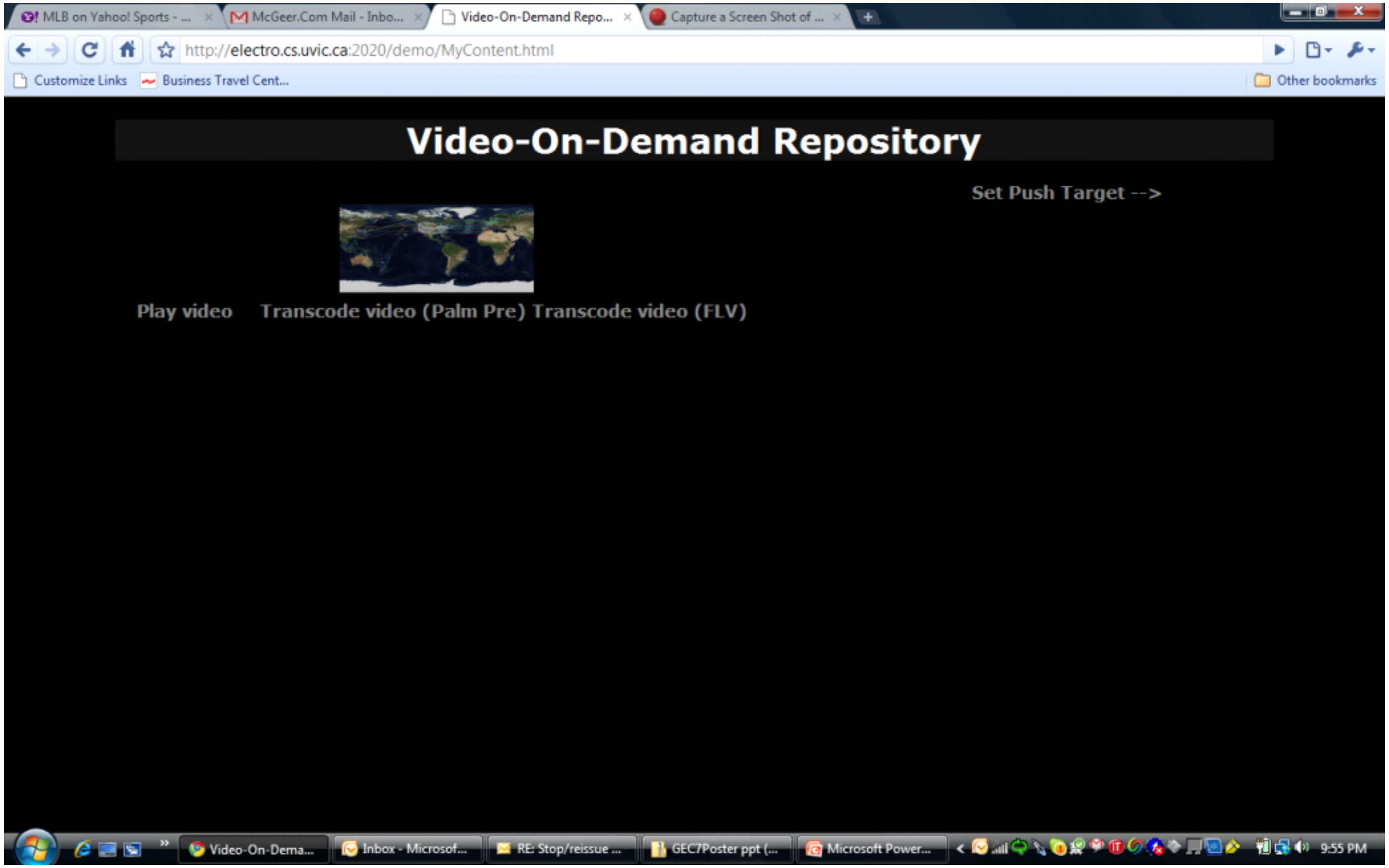
GEC8/GEC9
Demo site
Control/Displays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Inbox - Microsof...
RE: Stop/reissue ...
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THANKS!

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APPLICATIONS OF GENI X PLANETLAB

- General paradigm:
  - Use PlanetLab to send data to/from one or more Cloud Data Centers
    - BitTorrent-like CDNs….
  - Use PlanetLab to *collect* data from real-world testbeds
  - Use Cloud centers to do heavy computation
  - Use Cloud centers for persistent storage
- Second note:
  - Cloud Federation adds scalability, flexibility
  - GENI is inherently federated
  - Use GENI Federation Architecture to offer federation options for clouds

SOME EXAMPLE APPLICATIONS

- Office in the Cloud: use PlanetLab nodes as a cache for personal docs, email, checkpointing
  - Reduce bandwidth need at cloud center
- Local collection, local reduction, analysis in the Cloud
  - Measurement plane on PlanetLab
  - Wide-area distributed experiments (e.g., Cooperative Atmospheric Sensing Experiment)
- Data distribution to Cloud centers for analysis
  - Virtual astronomy, physics mining
- Peer-to-peer Twitter
  - Use social network to overcome locality-of-reference problem in Twitter

SOME EXAMPLE APPLICATIONS

– Data preparation in the Cloud, Data Distribution via GENI
  • E.g., Transcoding media for device form factor, distribution via CDN