Interfacing CoUniverse & Internet2 DCN

Petr Holub, Miloš Liška, Andrew Lake, Chris Tracey, Tom Lehman, John Vollbrecht, Brian Cashman

Sitola – Laboratory of Advanced Networking Technologies
CESNET, Internet2, Max Gigapop, Masaryk University
Demo supported by: TAMU, NLM, TMC

Internet2 Spring Member Meeting
Washington DC, 2009–04–29
Motivation

Demo

CoUniverse

CoUniverse & Internet2 DCN

Implementation

Future Work
Motivation: CoUniverse

● High-definition collaborative environments
  ▪ Using high-quality, high-definition media streams to build collaborative environment
    ◆ bandwidth demands comparable to network link speeds (10 GbE) requires careful planning and configuration of infrastructure
    ◆ lacks adaptivity to changing networking conditions
  ▪ Large numbers of components needed to build the environment
    ◆ each one of them needs to be configured
    ◆ hard to orchestrate them manually to build the desired environment
    ◆ virtually impossible to cope with network events manually
Motivation: CoUniverse

• CoUniverse is a framework to orchestrate interactive network-centric applications
  ■ GLIF and SuperComputing demonstrations
  ■ Introduction to High-Performance Computing class

• Fields where CoUniverse can help
  ■ audio/video transmissions
  ■ remote instrument control
  ■ generic network-centric application encapsulation
  ■ ... for scientific collaboration, telemedicine, etc.
Motivation: CoUniverse & Internet2 DCN

- Application-driven network allocation
  - if we can control applications, why not the network?
  - user should not be forced to allocate it manually
- CoUniverse is ideal for implementing this
  - it’s just another component to orchestrate
  - framework is general enough to implement it
CoUniverse & Internet2 DCN – Joint Tech Demo

Network Topology

Low-latency 1080i HD video using a network like this...

for switch addressing:
10.34.40.0/24
to be used on vlan3440
for debug and test
Internet2 SMM Demo

- Washington, DC – Bethesda, MD
  - collaboration with National Library of Medicine
- Washington, DC – Houston, TX
  - collaboration with Memorial Hermann Texas Medical Center
- What do we need to make this happen?
  1. network initialization
  2. monitor network and wait until it comes up
  3. startup of all applications and components
  4. monitor everything and react to events
  5. termination of all applications and components
  6. network tear-down
- … we don’t want this by hand, do we?
Internet2 SMM Demo

Spring Member Meeting
DCN - CoUniverse Presentation
With “Just-In-Time” Medical demos

VLAN 3105 - Ultragrid Video (10.1.1.0/24)
VLAN 3205 - Monitoring (10.10.10.0/24)
VLAN 3305 – Polycom/Ultragrid (10.20.20.0/24)

IDC circuit endpoints:
- **tagged** nlm.nih.gov or urn:ogf:network:domain=dragon.maxgigapop.net:node=CLPK:port=1-3-3:link=*  
- **tagged** smm09.internet2.edu or urn:ogf:network:domain=dragon.maxgigapop.net:node=CLPK8509:port=0-4-16:link=*  
- **untagged** utest.anna.internet2.edu or urn:ogf:network:domain=anna.internet2.edu:node=raptor1:port=UTEST:link=*  
- **untagged** memorialhermann.org or urn:ogf:network:domain=gigapop.gen.tx:node=switch1:port=0-1-22:link=*  

MAX/DRAGON IDC URL: https://idc.dragon.maxgigapop.net/axis2/services/OSCARS

Motivation
Demo
CoUniverse
CoUniverse & Internet2 DCN
Implementation
Future Work
Internet2 SMM Demo

- CoUniverse manages
  - network: DCN circuits
  - UltraGrid
    - $1920 \times 1080$, 60 Hz, interlaced
    - DXT compressed video (decompression runs entirely in GPU)
    - 250 Mbps bandwidth
    - 130 ms latency end-to-end
    - Mac sender and Linux receiver, over GE
  - Polycom HDX
    - $1280 \times 720$, compressed
    - 4 Mbps bandwidth
    - noticeably higher end-to-end latency
CoUniverse Building Blocks

- **Organization of the CoUniverse**
  - Collaborative Universes where actual collaboration takes place
    - partitions virtual space (like, e.g., Virtual Venues)
    - provides privacy for users (may enforce authentication and authorization of users)
    - limits size of the system
  - Multiverse
    - registration and lookup of Collaborative Universes
    - automatically joined by each node

- **Network organization**
  - control plane based on P2P substrate
    - maximize robustness of the network
    - distributes control messages, updates from monitoring, etc.
  - one or more data planes running over native network
    - maximize performance for the applications (typically throughput, latency, jitter)
CoUniverse Building Blocks

- **Components**
  - nodes: physical nodes, having one or more network interfaces, running individual orchestrated applications
  - proxy nodes: proxies and controllers for devices that can’t run CoUniverse directly (Polycoms, microscopes, etc.)
  - sites: aggregate of network nodes (e.g., you can tell you want stream from a specific site)
  - application groups: aggregate of applications
CoUniverse Building Blocks

- **Application Group Controller (AGC)**
  - controls operations in the Universe
  - contains media streams scheduler if needed
  - one AGC per application group
Self-organization in CoUniverse

- **Dynamic media streams scheduling:**
  - Schedule media streams produced by media applications on particular network links (plan step)
  - Scheduling media streams using bandwidth close to physical link capacity is hard
  - Scheduling based on set of constraints
    - producer constraints, consumer constraints, data distribution constraints, network link constraints

- **Resilience:**
  - Ability to react to changes/failures in the network infrastructure, media applications etc.
  - Achieved by monitoring, infrastructure changes and/or failures lead to new media streams schedule
Visualisation in CoUniverse

- overview of actual CoUniverse state for the user
- network topology visualization
- actually scheduled media streams

GLIF 2007 visualisation

Current development visualisation
CoUniverse & Internet2 DCN

- DCN interfaces
  - web interface for humans
  - web service interface (w/ security!) for machines

- Initializing and tearing circuits
  - network link can have associated one or more lambda links
  - DCN-specific lambda link: two endpoints (including identification, IDC and (tagged|untagged) interface) and requested bandwidth

- Integration of on-demand circuits with CoUniverse brings another level of uncertainty into scheduling
  - should I count on a network link I’m uncertain to get?
  - should I preallocate the network? (but there are $\frac{n^2-n}{2}$ bidirectional links!)

  - … see future work
Notes on Implementation

- **State of the CoUniverse**
  - goal is to have usable proof-of-concept implementation
    - research on self-organization, application orchestration, scheduling
    - real-life applications (science, education)
  - [https://www.sitola.cz/CoUniverse](https://www.sitola.cz/CoUniverse)

- **Open-source**

- **Implemented in Java, works on Linux, MacOS X, Windows**

- **P2P control plane**
  - based on JXTA 2.4.1
  - joining takes 2–30 s depending on the network

- **Internet2 DCN**
  - OSCARS API using Axis and Rampart
Future Work

- **CoUniverse**
  - ongoing research into scheduling
    - constraint based, graph based, genetic algorithms, user-friendly workflow support
  - improving code quality
  - direct support for more applications: embedding various types of streaming applications (microscopes, media streaming applications)

- **UltraGrid**
  - support for audio
  - support for other compressed formats (JPEG2000)
  - support for higher resolution (2K, 4K)
Future Work

- **DCN**
  - security needs to be scalable and developer-friendly
  - improvements in allocation speed of the DCN circuits
    - important for interactive applications (“I want the circuit NOW!”)
  - multi-point issues
  - renewing/modification of reservations
  - notification API instead of status polling
Acknowledgments

This project has been supported by a research intent “Optical Network of National Research and Its New Applications” (MŠM 6383917201) and “Parallel and Distributed Systems” (MŠM 0021622419).
Thank you for your attention!

Q?/A!

<hopet@ics.muni.cz>