Speakers

- Tom Lehman, Virnao
- Wenji Wu, Fermi National Accelerator Laboratory (FNAL)
- Xi Yang, University of Maryland/Mid-Atlantic Crossroads (UMD/MAX)
- Joe Mambretti, Northwestern University
- Harvey Newman, Caltech (California Institute of Technology)
Agenda

- Intelligent Network Services and SENSE Overview
- Big Data Express Overview
- Prototype Deployment and Demonstration Overview
- Future Vision and Work
- Questions and Discussion
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SENSE: SDN for End-to-end Networked Science at the Exascale

SENSE Research Team

Internet2 Global Summit
Intelligent Network Service Plane Session
March 08, 2019, Washington, DC

SENSE Team

Sponsor
U.S. Department of Energy
Office of Science
Advanced Scientific Computing Research (ASCR)
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- **University of Maryland/Mid-Atlantic Crossroads**
  - Tom Lehman
  - Xi Yang
  - Alberto Jimenez
Vision and Objectives

A new paradigm for Application to Network Interactions

• **Intent Based** – Abstract requests and **questions** in the context of the application objectives.

• **Interactive** – what is possible? what is recommended? let’s negotiate.

• **Real-time** – resource availability, provisioning options, service status, troubleshooting.

• **End-to-End** – multi-domain networks, end sites, and the network stack inside the end systems.

• **Full Service Lifecycle Interactions** – continuous conversation between application and network for the service duration.
SENSE

Application Workflow Agent

Architecture
Model Driven SDN Control with Orchestration

Intent Based APIs with Resource Discovery, Negotiation, Service Lifecycle Monitoring/Troubleshooting

Datafication of cyberinfrastructure to enable intelligent services

Realtime system based on Resource Manager developed infrastructure and service models
SENSE Resource Managers

Model Based Control and Orchestration

SENSE Orchestrator

Learn system states
Read/Sync data

Control

Feedback / Awareness

Automatic Operation

Change system states
Write / Sync data

Multi-Resource Modeling

Learn system states
Read/Sync data

Network Markup Language/RDF based Model Schema

Allow the machines to automate, iterate, react, and adjust to find solutions and not bring the humans in until absolutely necessary

SENSE Resource Manager

RM

DTN

NERSC

RM

Argonne

DTN

Fermilab

RM

Caltech

DTN

ESnet

MAX

UMD

SENSE Resource Manager

RM

DTN
SENSE Architecture

Data Migration of Cyberinfrastructure

Intent Based APIs with Resource Discovery, Negotiation, Option Queries

Application Workflow Agent

SENSE-Orchestrator API

Network Data Collection and Analytics

Service Specific Data

SENSE Orchestration

SENSE-RM API (Model Based)

Caltech

ESnet

FNAL

ANL

MAX

WIX

Internet2

UMD

Realtime System based on Resource Manager (RM) developed infrastructure and service models

Data Migation of Cyberinfrastructure to enable intelligent services
Request 20 Gbps P2P service between Caltech and Fermilab. If 20 Gbps not available, 10 Gbps is ok.

Service is not working, please check status.

What is the maximum bandwidth available for a P2P service between Caltech and Fermilab?

20 Gbps available for a P2P service between Caltech and Fermilab.

Request 20 Gbps P2P service between Caltech and Fermilab. If 20 Gbps not available, 10 Gbps is ok.

15 Gbps P2P service between Caltech and Fermilab instantiated.

Service is not working, please check status.

Failure on a network element, problem fixed.
Application to SENSE Interactions

- Transforms the network into a first class resource for workflow planning and optimization
- Allows applications to “query and negotiate” with network
- The SENSE infrastructure is designed to develop these types of services in DevOps manner, and customize for individual application agents.
- Cannot do every computation possible, but can do any computation desired.
Application Workflow Agent Services

- **Time-Block-Maximum Bandwidth (TBMB):** Application asks for a specific time block and would like to know (or provision) the maximum bandwidth available for a specific time period.

- **Bandwidth-Sliding-Window (BSW):** Application asks for a specific bandwidth and duration and provides an acceptable time window. For example, a request may be for 40 Gbps for a 10-hour time window, sometime in the next 3 days.

- **Time-Bandwidth-Product (TBP):** Application asks for “8 hours of transfer at 10Gbps” representing a TBP of 36 TBytes. The user also specifies an acceptable time window, and other options such as “prefer the highest bandwidth rate available”, or the lowest.
Application Workflow Agent Services

• **Immediate Provision:** If SENSE finds a resource path which satisfies the application request, provisioning starts immediately (after routine confirmations from both sides).

• **What is Possible?:** In this mode, SENSE simply conducts a “Resource Computation” and provides the results back to the requestor. No provisioning action is taken without further explicit requests from the user.

• **Negotiation:** One or more rounds of Resource Computation requests with subsequent provisioning request by the application user if desired.
SENSE Services - Data Plane Features

Data Plane Connectivity Services:
• Point-to-Point (Layer 2)
• Multi-Point (Layer 2)
• Layer 3 QoS/Priority

Options
• Layer 2 (with L3 addressing)
• Layer 3 Routed Network Connections
• Quality of Service (guaranteedCapped, guaranteed, bestEffort)
• Negotiation
• Scheduling, Batch Service Request
• Strict and Loose hops, Preemption, Lifecycle monitoring and debug
Use Cases

• Data Transfer Node Priority Flow
  – Deterministic end-to-end data transfers

• Exascale for Free Electron Lasers (ExaFEL)
  – Streaming the data from the LCLS online cache (NVRAM) to the SLAC data transfer nodes

• Big Data Express
  – Intelligent selection of WAN paths based on user requirements

• Future
  – LHC, Superfacility
SENSE Information

• SENSE Website
  – sense.es.net → Publications

• SENSE INDIS 2018 at SC18 Workshop Paper

• SENSE Demonstration movies:
  – Intelligent Network Services
  – Point to Point QoS
  – Multi Point service
  – Intent API Intelligent Services
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DEMO Topology & Configuration

FNAL:
- BDE Head Node
- AmoebaNet SDN Controller
- DTN (BDE4)

UMD:
- BDE Head Node
- DTN (180-148)
- DTN (180-149)
- SENSE Resource Manager
Sense, Big Data Express Cooperation

- Big Data Express and SENSE work together in real time to determine who is responsible for each segment in the end-to-end path.
- In this case, Big Data Express handled the local networking at Fermilab and SENSE handled the local network at UMD, along with the ESnet WAN network services.
- Automatic discovery possible as a result of SENSE model exchanges.
SENSE and BigDataExpress DEMO Movie

INTELLIGENT NETWORK SERVICE WITH SENSE AND BDE DEMO @ INTERNET2 GLOBAL SUMMIT 2019

Video Link: https://tinyurl.com/sense-bde-i2summit2019
Demo Highlights

• End-to-End Service Orchestration Capabilities
  – SENSE global resource modeling and control-feedback loop
  – Intelligent end-to-end SDN orchestration and workflow
  – BDE end-to-end transfer automation and orchestration

• API Driven Service Intents and Interactions
  – Service intent customized for BDE-to-SENSE interactions
  – Real-time feedback and service negotiation

• Improved Quality of Experience for End Users
  – Deterministic QoS as defined by user intent
  – Differentiated QoS control by SENSE and BDE at network edges
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Thanks!
Extra Slides
SENSE Network Resource Manager (RM)

Network-RM Functions/Roles:
- Responsible for a specific set of Network Resources
- Generate realtime MRML Model
- Evaluate and respond to SENSE Orchestrator information and service requests (including negotiation)
- Provision network resources in support of SENSE services
- Provide status, monitoring, and debug functions
SENSE DTN/End Site Resource Manager

EndSite/DTN-RM Functions/Roles:
- Responsible for a specific set of EndSite and DTN Resources
- Generate realtime MRML Model
- Evaluate and respond to SENSE Orchestrator information and service requests (including negotiation)
- Provision EndSite/DTN resources in support of SENSE services (includes networking stack of end systems)
- QoS provided via OpenFlow (Open vSwitch) flow prioritization and/or TC (FireQoS)
- Automatic dataflow initiation for path verification
SENSE Enabled DTNs

- SENSE DTNs can be deployed next to production DTNs
- No impact to standard DTN operations
- Just adds a “priority flow” feature

- Scheduled and guaranteed resources, network and end system
- Can be included as part of application workflow planning
SENSE-Orchestrator Functions and Process

- Scalable understanding and reasoning of end-to-end infrastructure and services
- Model driven computational intelligence
- Negotiation based service instantiation for distributed autonomous resource managers
- Flexible, domain specific user intent requests

User Intent Based API

SENSE-O

Intent Interpretation
MRML Model of Service Request

Model Build
Computation

MRML Model Delta
Service Workflow

MRML Model Deltas (Driver Specific)

Drivers
SENSE-EndSite-RM Driver
SENSE-Network-RM Driver
SENSE-EndSite-RM Driver
Other Drivers

Pluggable Model Computation Elements (MCEs)
- Point-to-Point Topology Service
- Multi-Point Topology Service
- EndSite Resources
- 1319 Routing and Address Assignment
- Multiple Domain Path (KSP)
- Information Requests
- Other MCEs

SENSE-RM MRML Models
SENSE-RM MRML Models

SENSE-EndSite-RM
SENSE-Network-RM
SENSE-EndSite-RM
Demonstration – Intelligent Network Service

Intelligent Network Service with SENSE and BDE Demo @ Internet2 Global Summit 2019
Demo Sequence

- 0:00, beginning
- 0:10, Big Data Express Portal
- 0:57, BDE user authenticates with FNAL and UMD sites
- 1:18, User instantiates a BDE end-to-end transfer service
- 1:40, BDE requests service from SENSE thru intent API
- 2:03, SENSE orchestrates E2E service based on BDE intent
- 2:26, BDE interacts with SENSE to manage service lifecycle
- 2:46, SENSE provision L2 path across ESnet and UMD Site
- 3:02, Allocates VLAN and IP, and reserves guaranteed bandwidth
- 3:33, BDE configures FNAL site SDN and QoS
- 4:02, DTN-to-DTN SDN is orchestrated by both BDE and SENSE
- 4:20, All is automated based on API with intent and interaction
- 5:06, BDE detects data path and initiates transfer automatically
- 6:26, SENSE DTN host QoS: Guaranteed vs Best effort
- 7:02, Service is terminated automatically when transfer is finished
- 7:27, Through same orchestrated API interactions
- 8:00, end
Demo Setup: FNAL-UMD DTN-to-DTN orchestration over SENSE Testbed

2Gbps TCP traffic on VLAN 3616 to QoS guaranteed SENSE path
SENSE – Service Portal Intent Editor

Dynamic Network Connection
BDE-IntentX

Connections

Type
Multi-Path P2P VLAN

Connection #1
Name
connection 1

Terminal #1
URI
urn:ogf:network:es.net:2013::chic-cr5-3_2_1:
VLAN Tag
any
Assign IP

Terminal #2
URI
VLAN Tag
any
Assign IP

Bandwidth
Capacity (in Mbps)
10000
QoS Class
guaranteedCapped

Schedule

Suggest IP Range #1
Start (A.B.C.D/Mask)
10.36.19.11/24
End (A.B.C.D/Mask)
10.36.19.11/24
Demonstration – QoS Traffic Monitoring
BDE-SENSE - Service Negotiation: Intent #1

```json
{
  "service_type": "Multi-Path P2P VLAN",
  "service_alias": "SENSE.Demo.BDE-any",
  "connections": [
    {
      "name": "connection 1",
      "terminals": [
        {
          "label": "any"
        },
        {
          "uri": "urn:ogf:network:es.net:2013::chic-cr5:3_2_1:+",
          "label": "any"
        }
      ],
      "bandwidth": {
        "qos_class": "guaranteedCapped"
      }
    },
    "queries": [
      {
        "ask": "maximum-bandwidth",
        "options": [
          {
            "name": "connection 1"
          }
        ]
      }
    ]
  }
}```
```json
{
    "service_type": "Multi-Path P2P VLAN",
    "service_alias": "SENSE.Demo.BDE-3619",
    "ip_ranges": [
        {
            "start": "10.36.19.11/24",
            "end": "10.36.19.11/24"
        }
    ],
    "connections": [
        {
            "name": "connection 1",
            "terminals": [
                {
                    "label": "3619",
                    "assign_ip": true
                },
                {
                    "uri": "urn:ogf:network:es.net:2013::chic-cr5:3_2_1:+",
                    "label": "3619"
                }
            ],
            "bandwidth": {
                "qos_class": "guaranteedCapped",
                "capacity": "10000"
            }
        }
    ]
}
```
Demonstration – Big Data Express
Demonstration – Big Data Express
Demonstration – Big Data Express