Software-Defined Fabrics for IoT at Scale

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Context

- The Challenge
  - By 2050
    - Over 70% of world population will live in cities
    - Occupy 2% of landmass
    - Consume 75% of resources

- The Opportunity
  - To enable *livable and sustainable* cities and urban regions
    - economic, environmental, social

- Our Focus
  - Platforms to enable Smart City Applications
  - Converged Cloud computing, SDN, and IOT
IOT at Scale

- Requirements
  - Secure and Private
  - Responsive
  - Scalable
  - Cost-effective

Sensor and Actuator Gossamer
A Layered Architecture

SaaS
- Portal
- Custom KPIs
- Urban Planning
- Congestion pricing
- ... 3rd Party Apps

BaaS
- Analytics Engines
- APIs
- Publish/Subscribe Overlay
- Algorithmic Engines

PaaS
- Information-Centric Data Dissemination
- End-To-End, Multi Domain, Orchestration

SDI Resource Management
- SDI Manager
- Topology Manager
- Monitoring & Analytics

Cloud Controllers
(SD) Network Controllers
Access/Things Controllers

Multi-Tier Software Defined Infrastructure

Phys. Resources

Things (Sensors/Actuators)
vCPEs (Local Gateways)
Access (Wireless/Optical)
Smart Edges
Backbone Network
Cloud Data Centers

SAVI
Traditional ITS Data Flow

- **Road Authorities**
  - Traffic Cameras
  - Lane Usage Status

- **Transit Operators**
  - Bus Movement Information

- **Public Safety Agencies**
  - Accident Reports

- **Municipalities**
  - Construction Incidents

- **Environment Canada**
  - Weather Conditions

- **Road Sensors**
  - Road Conditions

**Traffic Management Center**
Supporting Public & Private Providers

Public App Provider:
- ITS Services

Private App Provider:
- Traveler Assistance
- Personalized Routing
- Fleet Management

Content-based Routing (Publish/Subscribe)

Clients (publisher/subscriber)

Control

Sensing

Intelligence
Demo: CVST Portal of Greater Toronto Area Traffic

- http://portal.cvst.ca
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Application-Enablement in Multi-tier Clouds

- Multi-Tiered Cloud: Core, Smart Edges, Access, vCPE, fog

- **Management of Software-Defined Multitier Cloud**
  - Computing, Networking, FPGAs, GPUs, Software-Defined Radio
  - Integrated real-time resource measurement and monitoring

- **Software-Defined Network Services**
  - Integrated secure networking over SDN and legacy networks

- **vCPE/Sensors**
  - virtual Customer Premises Edge (vCPE) and sensors, local resources at customer premises, managed from the Smart Edge

- **Application Platform**:
  - E2E orchestration of applications across federated infrastructures
  - Spanning core, Internet, smart edge, programmable access, and sensors
SAVI Testbed

- Cross-Canada Testbed; L2 backbone
- Federated with GENI in the USA, Two SAVI nodes in US, L2 connectivity
- One SAVI node in Korea
SAVI SDI Architecture & JANUS Manager

- Each resource type controlled by specialized controllers
- Each controller communicates with logically central C&M framework
- **SDI Manager, Topology Manager, and Monitoring and Analytics**
- Exposes open interfaces for external users and entities
Janus Network Control Module

- No Broadcast
- Routerless IP
- Non-IP Traffic

- Quality of Service
- NFV Service Chaining
- Security
Flexible Creation of Smart Apps on virtualized Customer Premises Edge

**SAVI Smart Edge**

- Integrated Management
- **Management Portal**
- **Apps**
- **Janus**
  - Orchestration
- **MonArch**
  - Monitoring/Analytics

**Cloud + SDN**

**SAVI vCPE**

- **Smart Home**
- **Private Network**
- **Video Streamer**
Small SAVI vCPE

- Supports compute and networking virtualization
- Able to host multiple applications
- Connected to the SAVI Smart Edge with VPN technology

- Has all the capabilities provided from the virtualized system in SAVI (e.g. tenant isolation)
- Capable of leveraging advanced Features of SAVI SDI (e.g. NFV Service Chaining)
SAVI vCPE Use Cases

- Gateway for Internet of Things devices
- Web acceleration and service delivery point
  - NFVs such as proxy, firewall, IDS/IPS and VPN services
- Smart home and office
- Connected vehicles
- Smart Transportation
- Smart Cities (lighting, air quality, … , carbon footprint)
Monitoring CO$_2$

- **Sensor nodes**: consists of a carbon dioxide sensor and radio module
- **Relay nodes**: responsible for forwarding any received packet toward the destination
- **Control Room**: destination of sensor data and data aggregation point
Research Agenda

- **IoT Virtualization**
  - Sensors, Actuators, Networks

- **SD Fabrics for City-Scale Infrastructure**
  - Virtual Slices: Core + Smart Edge + vCPE + vIoT
  - Synergy with fiber-based broadband access
  - Synergy with wireless access: LTE, 5G, and more

- **IoT-scale data gathering and dissemination**
  - Software-defined Information Centric Networking
  - Distributed storage, processing and aggregation
  - Security and Privacy
  - Low-latency and QoS where needed

- **Intelligence at Scale**
  - Distributed analytics and deep learning
Conclusion

- The SAVI multitier cloud based on SDI can provide flexibility, performance, scalability and cost effectiveness to support smart city applications.

- CVST application platform supports creation of smart transportation applications.

- Together SAVI & CVST provide a template for smart city application platforms.
Thank You!