



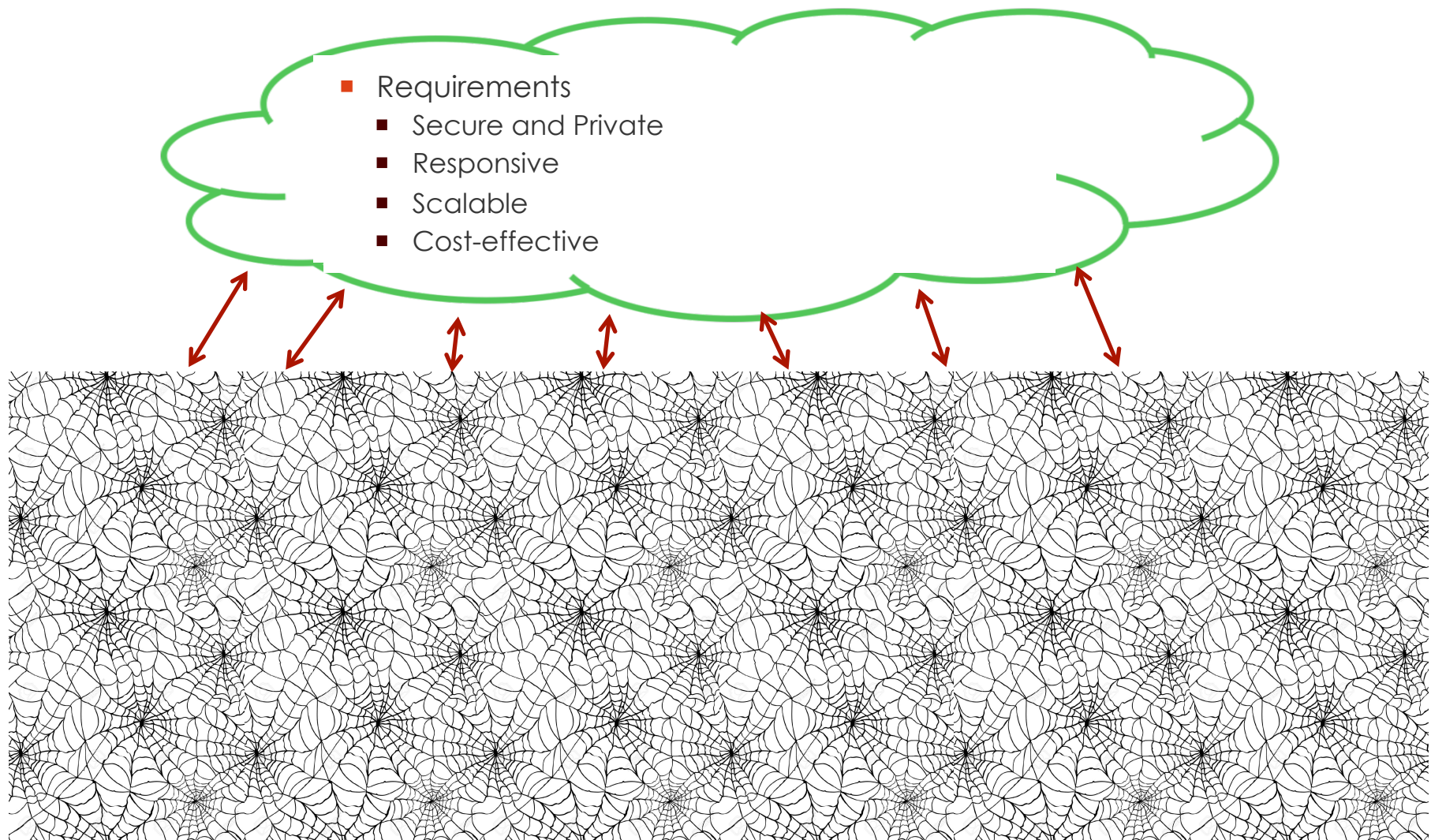
Software-Defined Fabrics for IoT at Scale

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Context

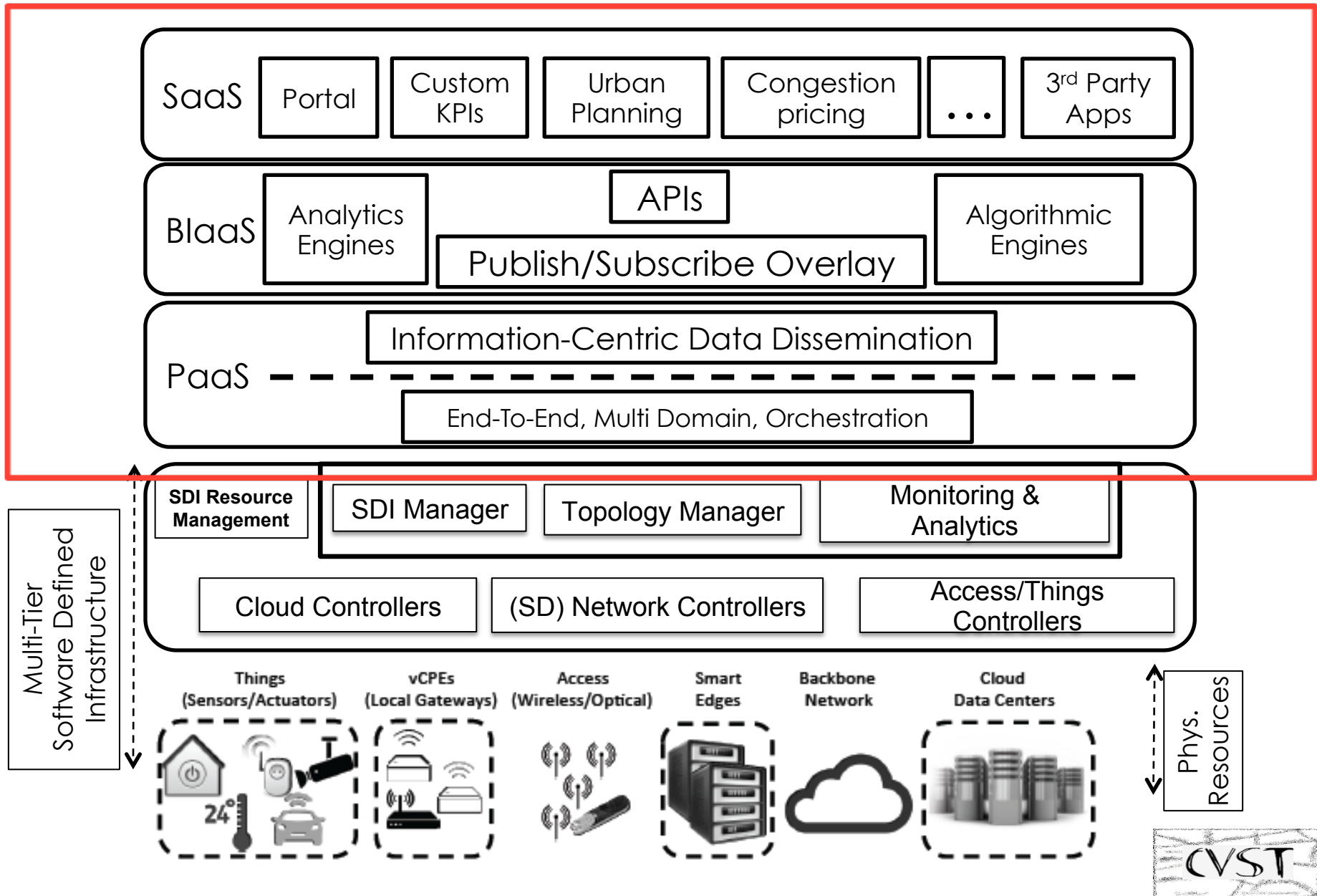
- The Challenge
 - By 2050
 - Over 70% of world population will live in cities
 - Occupy 2% of landmass
 - Consume 75% of resources
- The Opportunity
 - To enable **livable and sustainable** cities and urban regions
 - *economic, environmental, social*
- Our Focus
 - Platforms to enable Smart City Applications
 - Converged Cloud computing, SDN, and IOT

IOT at Scale

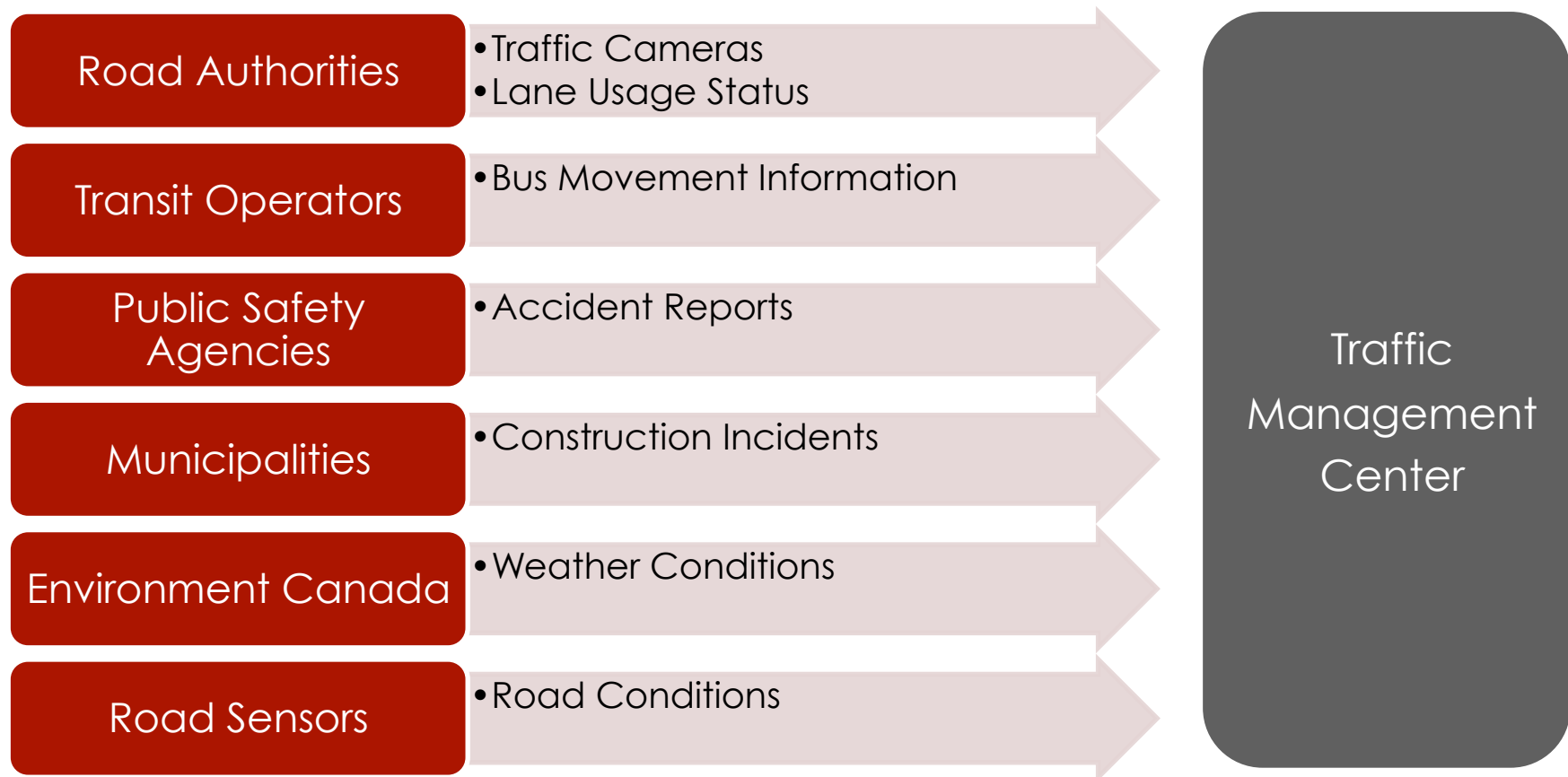


Sensor and Actuator Gossamer

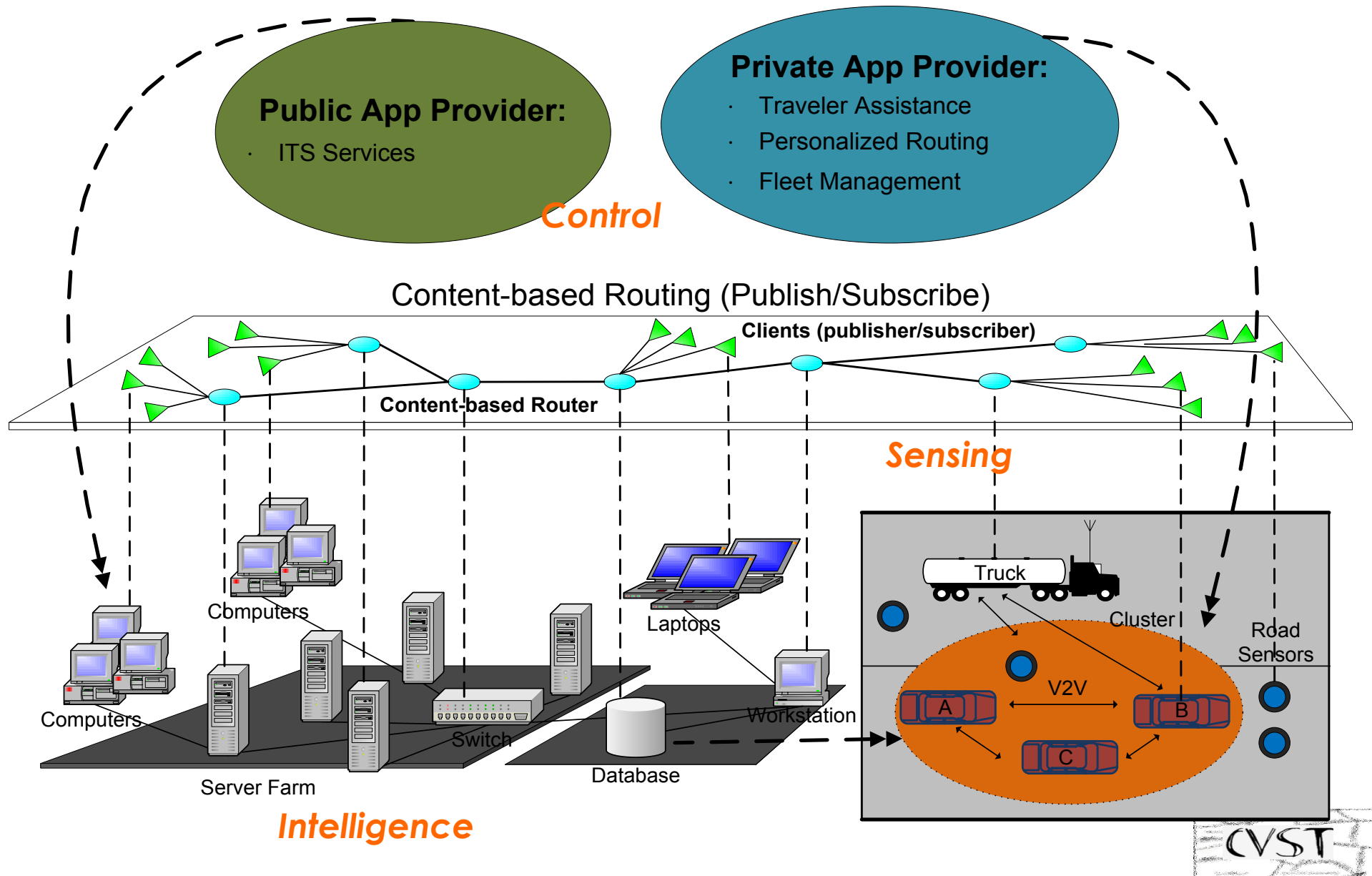
A Layered Architecture



Traditional ITS Data Flow



Supporting Public & Private Providers



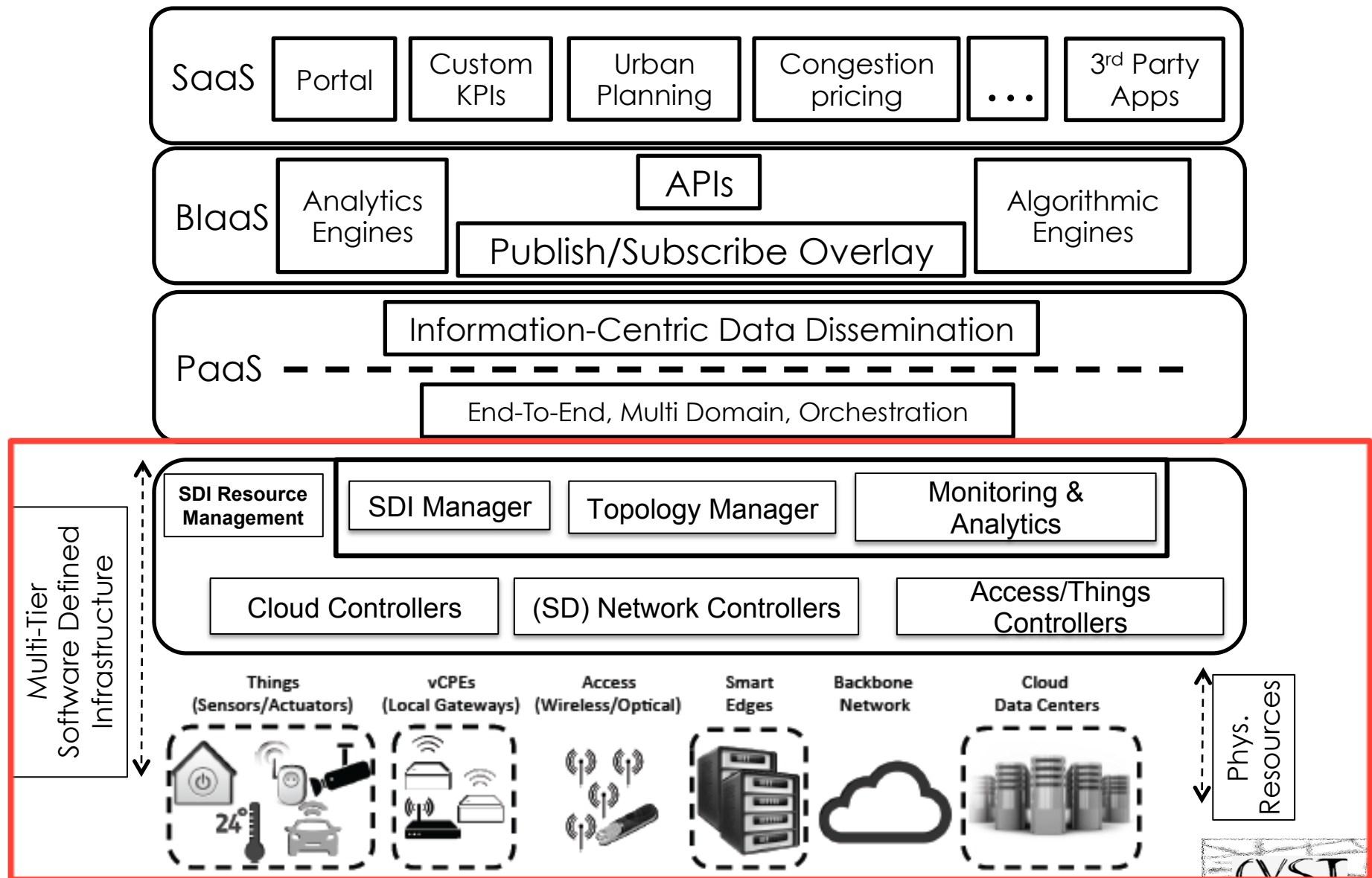
Demo: CVST Portal of Greater Toronto Area Traffic



- <http://portal.cvst.ca>

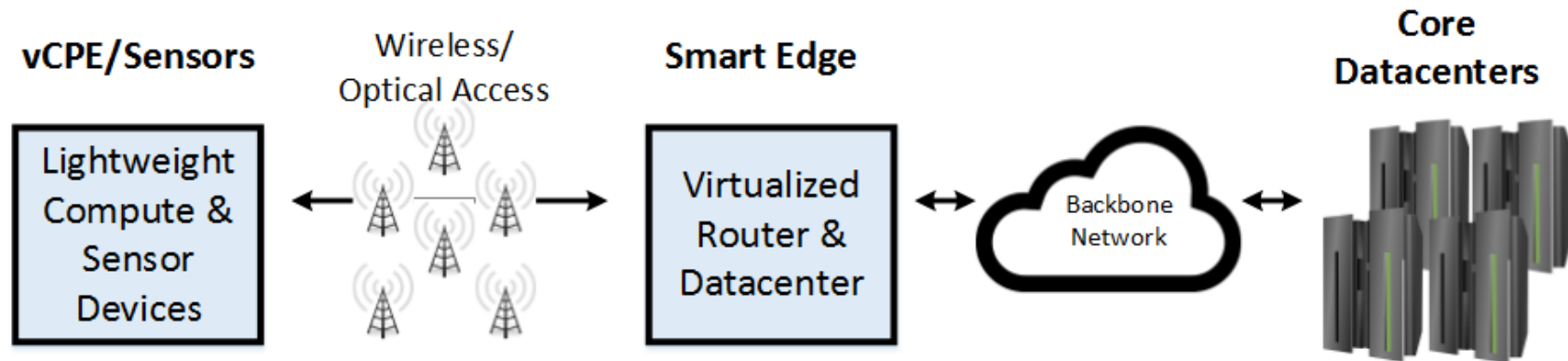


A Layered Architecture



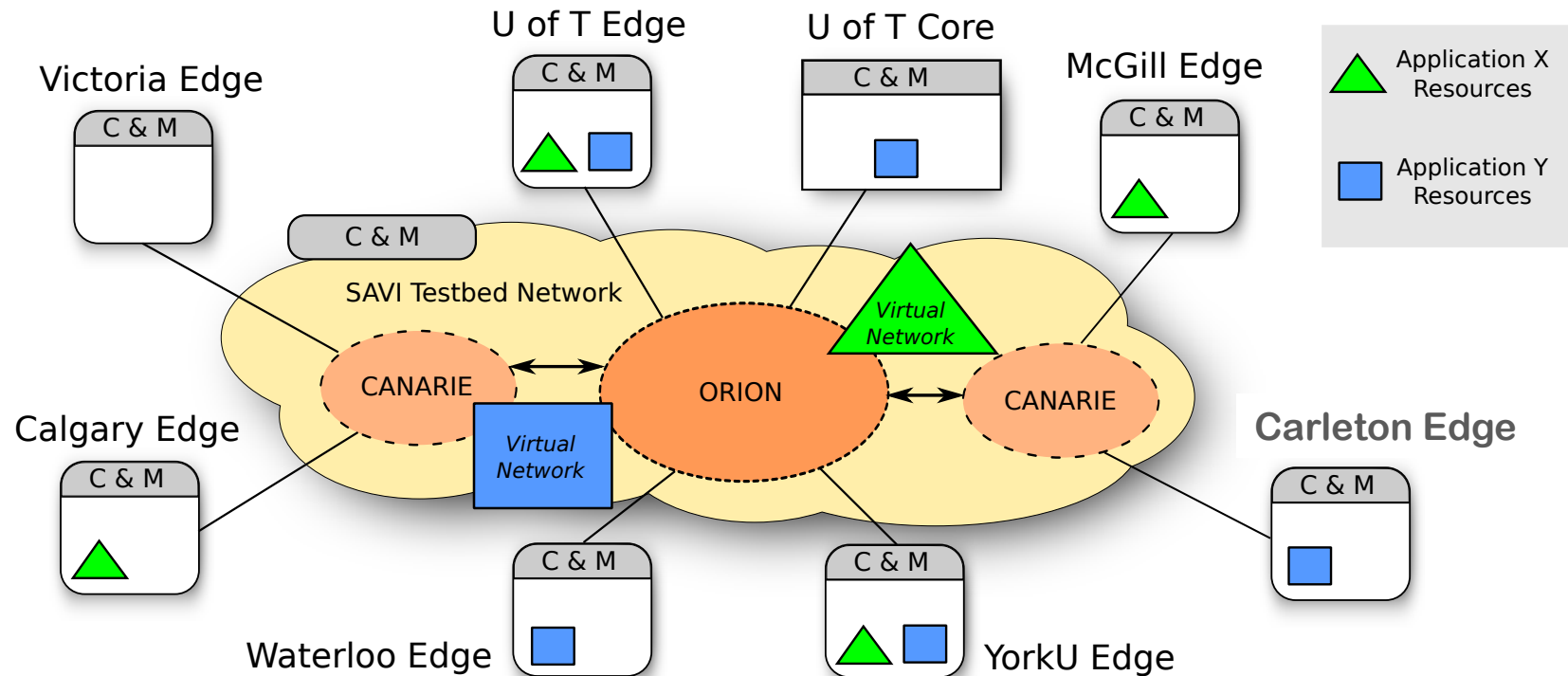
Application-Enablement in Multi-tier Clouds

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



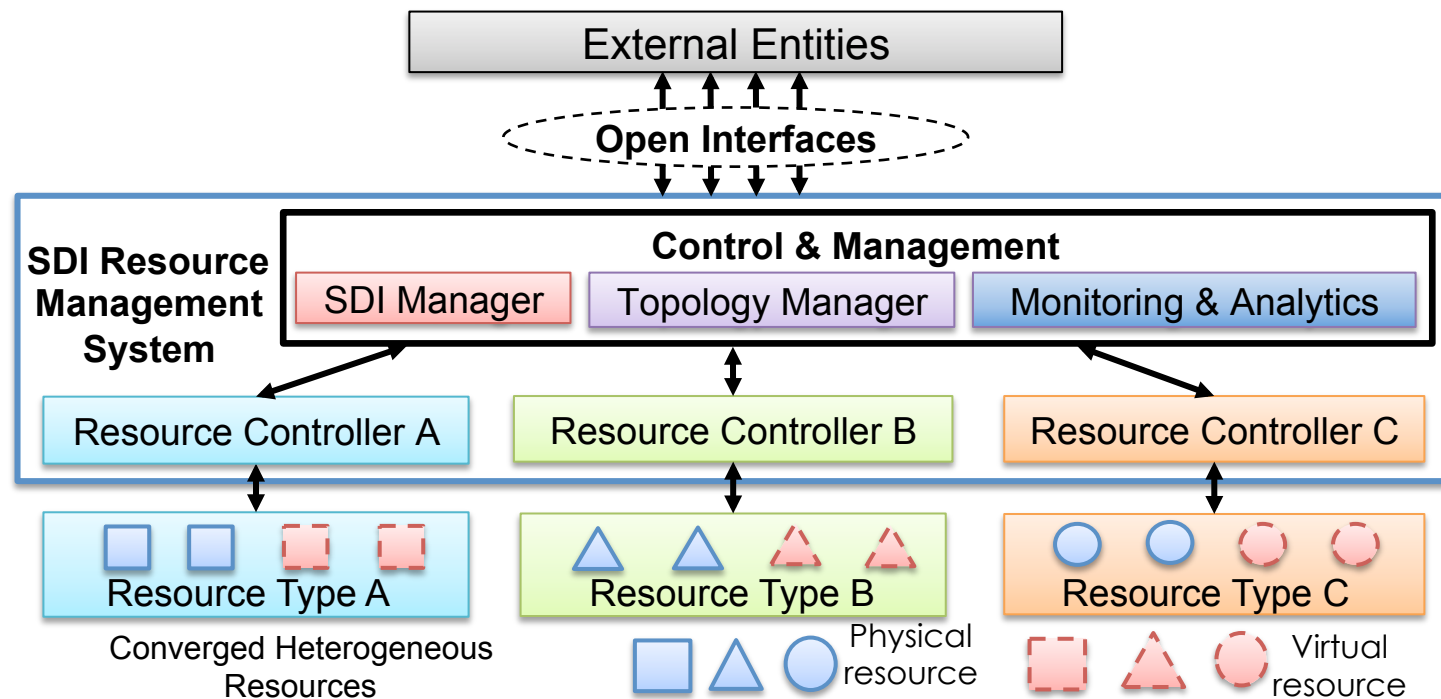
- **Management of Software-Defined Multitier Cloud**
 - Computing, Networking, FPGAs, GPUs, Software-Defined Radio
 - Integrated real-time resource measurement and monitoring
- **Software-Defined Network Services**
 - Integrated secure networking over SDN and legacy networks
- **vCPE/Sensors**
 - virtual 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



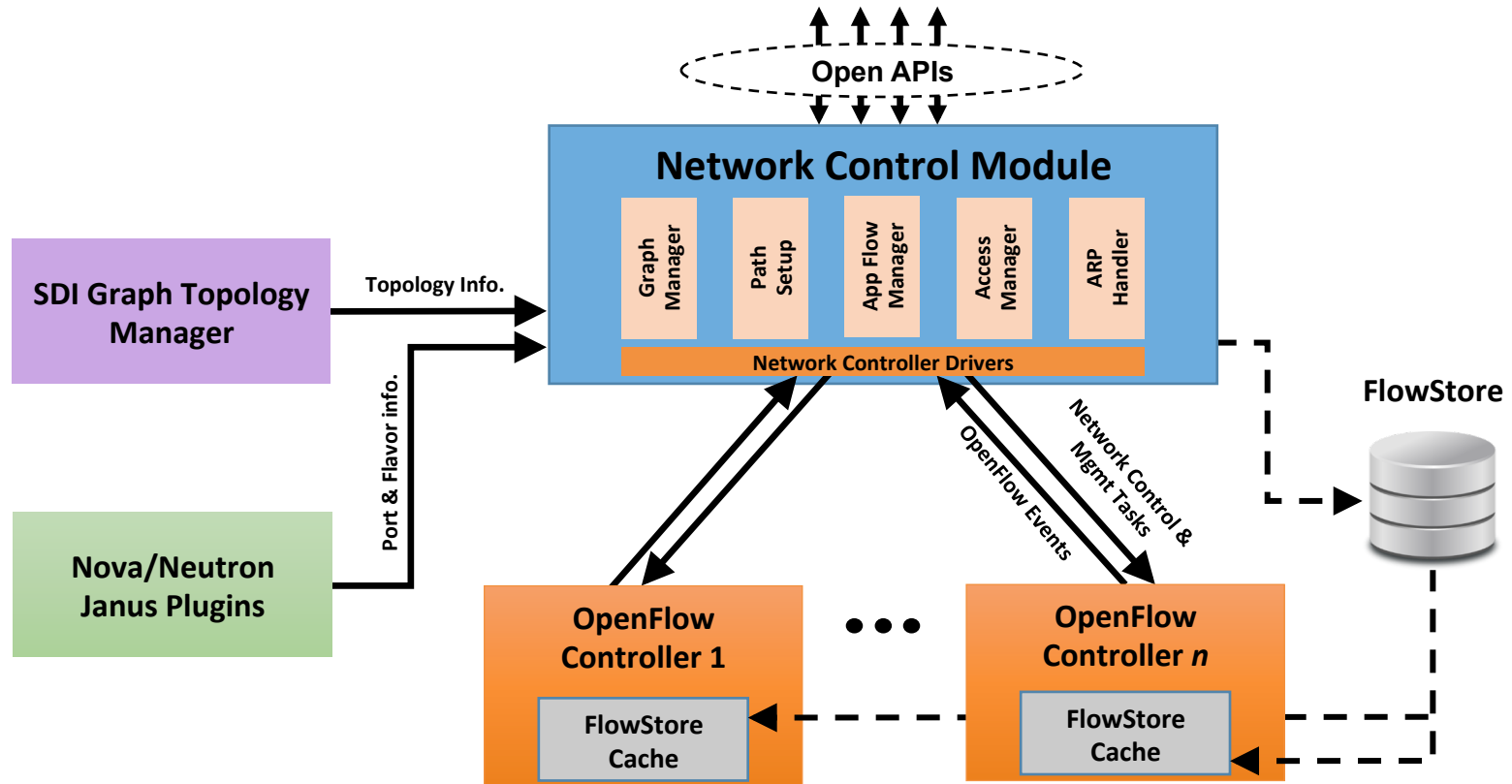
- Cross-Canada Testbed; L2 backbone
- Federated with GENI in the USA, Two SAVI nodes in US, L2 connectivity
- One SAVI node in Korea

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

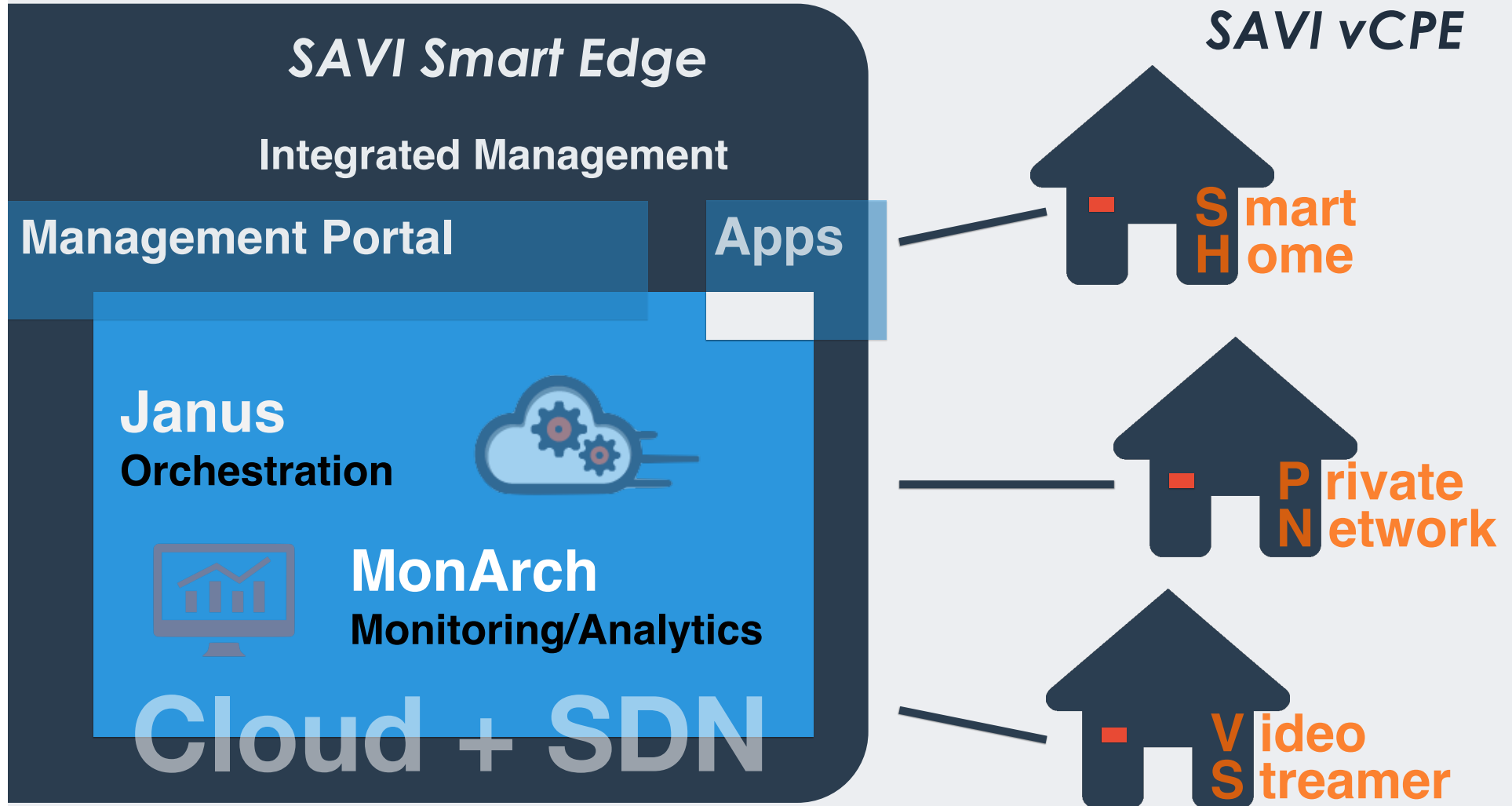
Janus Network Control Module



- No Broadcast
- Routerless IP
- Non-IP Traffic

- Quality of Service
- NFV Service Chaining
- Security

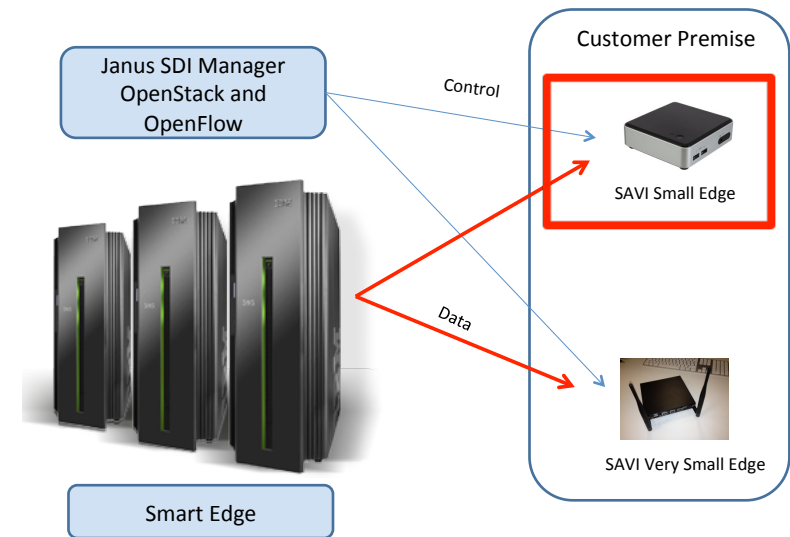
Flexible Creation of Smart Apps on virtualized Customer Premises Edge





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)





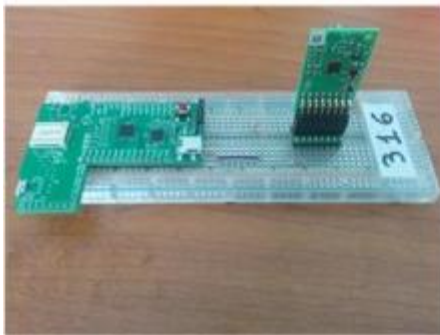
SAVI vCPE Use Cases

- 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 CO₂

Sensor Node



Relay Node



Control Room



- **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!

