

### StarlingX Enhancements for Edge Networking

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A Fully Featured Cloud for the Distributed Edge





### 01

#### **EDGE NETWORKING**

- What is Driving Edge Computing?
- Edge Computing Challenges
- Edge Networking Requirements

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#### WHAT IS STARLINGX?

- What Problems is StarlingX Solving?
- Intent of the StarlingX Project
- StarlingX Edge Virtualization
   Platform
- StarlingX Scales Small or Large

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### **TECHNOLOGY DETAILS**

- Network Performance and Efficiency
- Remote Management of Complex and Non-homogeneous Networks
- Reliability and Autonomous Site
   Operations with Limited Connectivity
- Enhanced Network Security

### 04

#### **BUSINESS CASES**

- China Unicom's Full Stack Cloud Network Architecture
- StarlingX\_\_\_Mapping to China Unicom's Edge-Cloud Platform Requirement

STATUS

05

- Upstream Scope & Flow
- OpenStack Networking Upstream Status
- Downstream Status

### 06

4'

### 3'

#### **FUTURE PLAN**

 Networking for Next-Gen Container Architecture

Quote



# What is Driving Edge Computing?

- A. Latency
- B. Bandwidth
- C. Data Locality
- **D.** Scalability
- E. Connectivity
- F. Security

"WHERE" Matters!



## Edge Computing Challenges







Sources: https://virtualrealitypop.com/different-types-of-vr-ar-devices-making-sense-of-the-spatial-computing-landscape-605efe5b9f17; https://datafloq.com/read/how-edge-computing-will-give-new-life-health-care/3715; https://www.autotrader.ca/newsfeatures/20170109/continental-zf-debut-new-autonomous-driving-tech-at-ces-2017/

# Edge Networking Requirements



### "Networking" Plays a Key Role at the Edge!

1	Network performance and efficiency Latency, Bandwidth	
2	Remote management of complex and non-homogeneous networks Data Locality, Scalability	
3	Reliability and autonomous site operations with limited connectivity Connectivity	
4	Enhanced network security Security	
5	Capex and Opex, Time To Market	



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# What Problems is StarlingX Solving?



- 1. Distributed infrastructure demands a different architecture
- 2. Managing a massively distributed compute environment is hard
- 3. The maturity and robustness of Cloud is required everywhere

# Intent of the StarlingX Project



### **Re-Configure Proven Cloud Technologies for Edge Compute**

- Orchestrate system-wide
- Simplify deployment to geographically dispersed, remote Edge regions
- Provide a deployment-ready, scalable, highly reliable Edge infrastructure software platform





# StarlingX – Edge Virtualization Platform

- Network performance and efficiency
- Remote management of complex and nonhomogeneous networks
- Reliability and autonomous site operations with limited connectivity
- Enhanced network
   security

**Upstream Projects OpenStack Components** Magnum Horizon Swift-API Cinder Ironic Murano Heat Telemetry Nova Keystone Neutron Glance **Integration Project New StarlingX Services** Infrastructure Orchestration X X X Configuration Software Fault Host Service Management Management Management Management Management **Upstream Projects** Some of the Open Source Building Blocks Used by StarlingX Ceph QEMU **Open vSwitch** DPDK SR-IOV Collectd libvirt **Kubernetes** Linux

### A Fully Featured Cloud for the Distributed Edge

# StarlingX Scales Small or Large



Physical Server

 Single Server **Scalability For The Edge** - Runs all functions **Single Server Dual Server Multiple Server** Top of Rack VM VM VM VM VM VM Dual Server VM VM VM Compute Compute - Redundant design Compute Control Control Storage Storage VM VM VM • Multiple Server Compute VM VM VM - Fully resilient and Compute Control geographically Control distributable Control Storage Storage Storage 1:1 Protected Pair of Servers STARLINGX



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### **Network Performance and Efficiency**



# **Mission-ready Network Performance**



- High performance Node-to-Node, VM-to-VM networking
  - Enabled:
    - OVS-DPDK
    - SR-IOV
    - PCI-passthrough
  - WIP for OpenStack Upstream
    - SmartNIC/FPGA
- Real-time and low latency enhancements to KVM
  - Reduced variability of interrupt latency
  - Reduced high resolution timer latency
- "Hardware Acceleration for Edge Networking"
  - Thu 15, 11:40am 12:20pm, Level 1 Hall A1





# **Configuration Management**



Acceleration technology support & Optimized configurations for Edge Cloud

- Manage Installation and Configuration
  - Auto-discover new nodes in an edge site
  - Manage installation and configuration parameters (e.g. Neutron config, agent parameters etc.)
- Nodal Configuration
  - Network Interfaces (DPDK)
- Inventory Discovery
  - Physical NICs (# and bandwidth)
  - H/W acceleration devices for edge networking (SR-IOV, SmartNIC etc.)



### System Configuration and Setup



# Improved Network Efficiency

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- Based on OpenStack Neutron
- L2/L3 scheduling/re-scheduling
  - Bulk operations; move away unnecessary operations
- L2/L3 agent
  - Event driven sync task
  - Stale RPC message handling
- Concurrency scenario enhancements
- L2POP
  - Registration mechanism for extension of L2POP fdb information
- VLAN transparent support
- QoS, BGP-eVPN, SFC...





### Remote Management of Complex and Non-homogeneous Networks



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# Host Management

Improved low touch manageability & Reliability

- Full life-cycle management of the host via REST API
- Detect and automatically handles host failures and initiate recovery
- Support automated and user level cluster connectivity tests
- Improve the way physical network topology is presented to the cloud/edge operator
- Monitoring and alarms for:
  - Critical process failures (etc. L2/L3 agents)
  - Resource utilization thresholds, interface states



### Vendor Neutral Host Management

# Network Segment Management



Improved low touch manageability & Scalability

- Based on OpenStack Neutron
- Manage the underlying network segment ranges via REST API
  - Full network orchestration
  - No direct interact with host config
- Control the segment ranges globally or on a per-tenant basis
  - Complex and non-homogeneous network infrastructure deployments at the Edge
  - Varied business requirements
- Dynamic segment range scaling



#### **External Physical Network Infrastructure**

### Network Segment Range Management



# Reliability and Autonomous Site Operations with Limited Connectivity



# L2/L3 Rescheduling

Enhanced high availability & Reliability

- Based on OpenStack Neutron
- Automatic rescheduling of DHCP servers and routers:
  - From offline L2/L3 agents to online L2/L3 agents
  - When new agents become active
  - When agents become overloaded
- Evaluation WIP:
  - Manual rescheduling via:
    - Script
    - API
  - Redistribution based on more sophisticated methodologies with additional info - CPU, memory, etc.
  - Re-configure default settings (L3-HA)





# Fault Management

Enhanced high availability & Reliability

- Framework for infrastructure services via API:
  - Set, clear and query customer alarms & events of different severity levels
  - Generate customer logs for significant events
- REST API alarms & events management
- Operator Alarms & Logs
  - On Platform Nodes & Resources
  - On Hosted Virtual Resources
- Network fault management
  - Network connectivity, ports, interfaces, Neutron agents
  - ML2 drivers
  - BGP peers





### Fault Alarming and Logging



# Infrastructure HA & Orchestration



Enhanced high availability & Reliability – A complete stack

- Manage and orchestrate VM carrier grade and high availability capabilities
  - Auto-healing of failed instances
  - Raising and clearing operator alarms
  - Generating operator logs about instances
- Orchestrate the migration of instances off of a compute host
- Automatically migrate VMs through procedure
- Controller fail-over
- Service monitoring and migration



### HA and Live Migration for VMs



### **Enhanced Network Security**



# **Enhanced Network Security**



- Based on OpenStack Neutron
  - OVS-DPDK firewall driver
    - Evaluation of security group implementations
    - Openflow + conntrack based security group: user-space, stateful, native
- Patching support via SW management



### **OVS-DPDK Security Group**





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- Quote

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 Networking for Next-Gen Container Architecture

STARLINGX

Upstream Scope & Flow

Downstream Status

OpenStack Networking Upstream

### China Unicom's Full Stack Cloud Network Architecture



The 5G network of China Unicom will be an *Elastic*, *Open*, *Efficient*, *Agile* network based on Regional DC, Local DC, Edge DC and Access CO, which will quickly respond to and shorten the deployment time of new services.



# StarlingX\_\_\_Mapping to China Unicom's Edge-Cloud Platform gr







### StarlingX Deep Dive\_\_\_Fault Management & Event Suppression (Mapping to ETSI Interface Requirement)

As ETSI GS MEC 010-1 V1.1.1 (2017-10) (*Mobile Edge Computing (MEC); Mobile Edge Management; Part 1: System, host and platform management*) defined:

#### 7.3.1 Fault Management interface

For Alarm Management, the following 3GPP defined IRPs are used:  $\ _{*}$ 

- ETSI TS 132 111-2 [4]: "Digital cellular telecommunications system (Phase 2+); Universal Mobile Telecommunications System (UMTS); LTE; Telecommunication management; Fault Management; Part 2: Alarm Integration Reference Point (IRP): Information Service (IS) (3GPP TS 32.111-2)".
- ETSI TS 132 332 [5]: "Digital cellular telecommunications system (Phase 2+); Universal Mobile Telecommunications System (UMTS); LTE; Telecommunication management; Notification Log (NL) Integration Reference Point (IRP); Information Service (IS) (3GPP TS 32.332)".

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Platform	~		
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Provider Network Topo	logy 100	Platform CPU threshold exceeded; threshold x%, actual y%. CRITICAL @ 95% suppressed Unsi	uppress Event
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System Configura	ation	VSwitch CPU threshold exceeded; threshold x%, actual y% .	
计算	> 100	102 CHITICAL @ 95% suppressed Unst MAJOR @ 90%	uppress Event
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网络	> 100	Memory threshold exceeded; threshold x%, actual y% . CRITICAL @ 90% unsuppressed	oress Event
王续	. 100	MAJOR @ 80% MINOR @ 70%	
Jane and		host= <hostname>.filesystem=<mount-dir></mount-dir></hostname>	
分管理	>	File System threshold exceeded; threshold x%, actual y% .	



### StarlingX Deep Dive\_System Configuration

(Mapping to ETSI Interface Requirement)



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#### As ETSI GS MEC 010-1 V1.1.1 (2017-10) (Mobile Edge Computing (MEC); Mobile Edge Management; Part 1: System, host and platform management) defined:



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Eault Manager

Software Managemen

Provider Network

#1.07

留理员 / Platform / Provider Network Topology Provider Network Topology

III Hide Labels

Compute Hosts

9/19/2018, 3:43:25 PM C: O M: O m: O W: O

### StarlingX Deep Dive - VM HA Acceleration (Not ETSI Required but critical to Edge)





controller-0:~\$ ping 172.16.140.152   awk '{ print \$0"\t" st	rftime("%H:%M:%S",systime()) }
PING 172.16.140.152 (172.16.140.152) 56(84) bytes of data.	10:52:20
64 bytes from 172.16.140.152: icmp_seq=1 ttl=63 time=0.468 ms	10:52:20
64 bytes from 172.16.140.152: icmp_seq=2 ttl=63 time=0.265 ms	10:52:21
64 bytes from 172.16.140.152: icmp_seq=3 ttl=63 time=0.234 ms	10:52:22
64 bytes from 172.16.140.152: icmp_seq=4 ttl=63 time=0.218 ms	10:52:23
64 bytes from 172.16.140.152: icmp_seq=5 ttl=63 time=0.230 ms	10:52:24
64 bytes from 172.16.140.152: icmp_seq=6 ttl=63 time=0.206 ms	10:52:25
64 bytes from 172.16.140.152: icmp_seq=7 ttl=63 time=0.226 ms	10:52:26
64 bytes from 172.16.140.152: icmp_seq=8 ttl=63 time=0.232 ms	10:52:27
64 bytes from 172.16.140.152: icmp_seq=9 ttl=63 time=0.230 ms	10:52:28
64 bytes from 172.16.140.152: icmp_seq=10 ttl=63 time=0.244 ms	10:52:29
64 bytes from 172.16.140.152: icmp_seq=11 ttl=63 time=0.235 ms	10:52:30
64 bytes from 172.16.140.152: icmp_seq=12 ttl=63 time=0.252 ms	10:52:31
64 bytes from 172.16.140.152: icmp_seq=13 ttl=63 time=0.245 ms	10:52:32
64 bytes from 172.16.140.152: icmp_seq=14 ttl=63 time=0.217 ms	10:52:33
64 bytes from 172.16.140.152: icmp_seq=15 ttl=63 time=0.237 ms	10:52:34
64 bytes from 172.16.140.152: icmp_seq=16 ttl=63 time=0.253 ms	10:52:35
From 172.16.130.1 icmp_seq=46 Destination Host Unreachable	10:53:08
From 172.16.130.1 icmp_seq=47 Destination Host Unreachable	10:53:08
From 172.16.130.1 icmp_seq=48 Destination Host Unreachable	10:53:08
64 bytes from 172.16.140.152: icmp_seq=49 ttl=63 time=998 ms	10:53:09
64 bytes from 172.16.140.152: icmp_seq=50 ttl=63 time=0.191 ms	10:53:09
64 bytes from 172.16.140.152: icmp_seq=51 ttl=63 time=0.244 ms	10:53:10
VM Restored in 34s (CentOs	5, 800M)
,	,
Diffstat	



### StarlingX Deep Dive - Controller HA Optimization (Not ETSI Required but critical to Edge)





		Fault Managem	nent - Akraino Edge Stack - Mozilla Firefox
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Host Inventory	Active	Alarms	Show Suppressed Hide Suppressed 过滤
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Provider Network Topology	Alarm ID	Reason Text	Entity Instance ID
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计算 >		failure. Auto- recovery in	
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### StarlingX Deep Dive - Inventory Management (Not ETSI Required but critical to Edge)



- Network Interfaces (DPDK)
- Physical NICs (# and bandwidth)
- H/W acceleration devices for edge networking (SR-IOV, SmartNIC etc.)

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ens6	oam	ethernet	-	ens6	• []			-	MTU=1500	
ens7	mgmt	ethernet	-	ens7	• []			-	MTU=1500	
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eth1001	-	ethernet	-	eth1001	• []			-	MTU=1500	
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# Quote from China Unicom\_StarlingX Release



"Comparing to the cloud in deployed in core-network, edge computing is requesting more capabilities on hands-off operation, remote management, telco-grade service reliability, telco-grade latency and open interfaces.

We had run a full validation on StarlingX in the past 6 months. StarlingX improved efficiency on highavailability in both VM and controller level. It also optimized the required nodes number to fit edge deployment scenarios. Features were added in fault management, rolling upgrading, inventory discovery and VNF acceleration, which are the interfaces recommended in ETSI MEC RA. StarlingX provided capability in VM-applications/VNFs hosting, it also can be extended to support containerized applications in the future.

It is one of the top strategies to China Unicom to build an "open" edge platform to provide open interfaces, support ecosystem applications hosting and avoid vendor lock-in. As an "Open Infra" technology for edge computing, StarlingX will play an essential role in China Unicom's edge strategy."



Dr. Dan Chen, Senior Director of Edge Computing, China Unicom





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Upstream Scope & Flow

Downstream Status

OpenStack Networking Upstream

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#### **FUTURE PLAN**

 Networking for Next-Gen Container Architecture

Quote



# Upstream Scope & Flow

- StarlingX upstreaming scope
  - OpenStack components
  - Other Open Source blocks

• StarlingX upstreaming work flow





# **OpenStack Networking Upstream Status**

- StarlingX upstreaming progress (by Oct'18)
- Align with upstream!
  - Target **ZERO** patch
  - Update to OpenStack
     Stein for the StarlingX
     2019.07.0 release.



OpenStack update in StarlingX: July'19 release will use Stein





# **Downstream Status**

- StarlingX enhancements:
  - OVS-DPDK firewall driver
  - vSwitch configurability
  - OVS LLDP (Link Layer Discovery Protocol ) inventory
  - OVS rx multi-queue affinity
- Containerized OpenStack services:
  - Generalized interface and network configuration for Kubernetes deployments
  - Enable vSwitch functions based on nodal labels





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STATUS

05

- Upstream Scope & Flow
- OpenStack Networking Upstream Status
- Downstream Status

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#### **FUTURE PLAN**

 Networking for Next-Gen Container Architecture

Quote

# 

# Networking for Next-Gen Container Architecture

- Container Architecture
  - Containerized OpenStack Service
    - Containerize OVS-DPDK: Support OVS-DPDK in OpenStack-HELM
  - Containerized Infrastructure (VNF):
    - Accelerated container networking with SR-IOV, OVS-DPDK and SmartNIC/FPGA
    - Support multiple interface
    - Support VM by virtlet
    - Multi-tenancy support for containers
    - Support for additional container runtimes including kata containers
    - Support SFC
- Support Time Sensitive Networking
- Integrate with ONAP and ONAP multi-cloud
  - Orchestration and Management for Edge Application with ONAP
    - Wed 14, 3:20pm 4:00pm, Level 1 Hall A1
- NEV (Network Edge Virtualization) SDK integration
  - reference libraries and APIs for MEC (Mobile Edge Computing)



### Full Support for VMs and Containers



# Thank You! Q&A

