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INC - Integrated Network Control

Introduction and motivation

For at least two decades, the benefits of integrating multiple voice and data services have been discussed and sought after in the telecommunications marketplace. Some of the first that come to mind are lower capital and operating expenditures compared with separate voice and data networks. The multiplicity of voice and data services, however, with their various operational time-scales and quality requirements, has nonetheless resulted in separate management and control for the respective services. Multiple fault management requirements are contributors to divergent platforms and controls. For example, financial data applications may require re-convergence of IP routers within seconds or tens of seconds. Network routing protocols (e.g., Border Gateway Protocol) may have timers operating on the order of one or two hundred milliseconds. The protection switching requirement for POTS (plain old telephone services) is usually on the order of 50 milliseconds. Gigabit routing systems often offer only modest 1+1 fault protection with re-convergence on the order of two or three minutes. In addition, the physical or logical places within the network for fault detection and resolution differ across services. So the realization of integrated network control platforms to effectively manage the multiplexed hierarchy of packets, cells, frames and wavelengths is central to obtaining the envisioned benefits. Paradoxically integrated management and controls, however, are often missing from voice and data integration discussions. Rather the seven-layer OSI stack generally persists despite separate and uncoordinated network protection time scales and schemes.

So the goal of this project is to define core elements of the language needed to integrate the management and control of a multiplexed hierarchy of packet, cell, frame and wavelength services, called herein Integrated Network Control (INC).

High-level description

The INC language provides services and calculator-like functions for the multi-layer entities of the OSI stack. As an entity, the INC supports and participates in multiple processes within the telecommunications environment:

- Order processing and validation: verification and storing of customer identification parameters
- Service creation – automatic instantiation of the required features for a service
- Policy enforcement – real-time call admission and service level implementation
- Fault management – multi-layer coordination and bundling

The hardware architecture associated with the INC is outside the scope of this project. In addition the real-time components of the solution are also out of scope.

Key INC components are cataloged by function as summarized in Table 1.

Function	Description
Order	validates requests and physical port-level capacities
Connect	links logical entities within port-level structures
Configure	Invokes the logical provisioning engines to add the logical parameters
Policer	Enforces end-to-end traffic admittance and shaping policy
FaultDetector	Manages fault conditions and implements recovery schemes
MoneyBag	Biller

Table 1. Function summary

Application

The INC functions can be applied in an internetworking environment. This environment, for example, could include one or more of the following subsystems, each with its own proprietary operating system and programming interface.

- Cisco routers running IOS
- Juniper routers running JUNOS
- Lucent ATM switches
- Ciena cross-connects
- Fujitsu wavelength division multiplexing systems

After each subsystem passes its initialization process, the INC is used to select and bundle the applicable parameters from each subsystem as required to satisfy the end-to-end requirements and constraints. INC provides the functions that coordinate and instantiate end-to-end provisioning in real-time. Each subsystem is abstracted as a functional block and logically integrated via the INC functions. So while each subsystem maintains its inherent characteristics, the INC provides the glue and intelligence that enable the sum of the subsystems as one entity.

Example syntax

Add Order (system) = $\sum$ Order(site, subsystem) for subsystem (0 to N)
Delete Order (system) = $\sum$ Order(site, subsystem) for subsystem (0 to M)
Add Connect(system) = Order (system)
Update Connect(system) = Order(system)

Illustrative program

Inputs

The site identifiers and subsystem parameters are inputs to the Order module. An example of the inputs are provided in Table 2

Site (identifiers)	Subsystem (parameters)
Near-end customer premise	CPRouter1 (Cisco 3800 series router)
Near-end transmission	None
Near-end cross-connect	None
Near-end network access	NtwkRouter2 (Juniper M320 router)
Near-end long-haul TX(1)	FibOp3 (Ciena CWDM)
Intermediate long-haul RX(1)	FibOp3
Intermediate long-haul TX(2)	FibOp5 (Fujitsu DWDM)
Far-end long-haul RX(2)	FibOp5
Far-end network access	NtwkRouter2
Far-end cross-connect: CRX9	CRX9 (Ciena cross-connect)
Far-end short-haul TX(1): FibOp8	FibOp8 (Lucent-Alcatel SR1)
Far-end short-haul RX(1)	FibOp8
Far-end customer premise	CPRouter2 (Cisco 3800+ series router)

Table 2. Order inputs

Function implementations

Order

The Order function validates:

1. Customer identification
2. Port capacity
3. Logical channel identification
4. Compliant traffic policy
5. FaultDetector = Null
6. Biller = Active

Connect

When Order function is complete, the Connect function links all logical entities.

Policer

When the Connect function is complete, the Policer enforces applicable traffic policy and shaping.

FaultDetector

When the Connect function is complete, the FaultDetector is activated with applicable threshold and recovery schemes.

Biller

When the Connect function is complete, the Biller is activated with the applicable timer and usage criteria.

Outputs

The INC outputs are the outputs of each of the respective functions listed above.

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Summary

Integrated network management and real-time control are key features that have yet to be realized in multi-service telecommunications networks. While this project introduces only a portion of the INC platform, the INC in its entirety provides key software and hardware components to efficiently support real-time internet telephony and data services.

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