Declarative, Distributed Configuration
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Relationship With SDN

SDN Motivations
• Planning network as a whole is hard
• Configuration is hard
• Deploying new protocols e.g., for virtualization, is hard
• Control and data planes are merged

SDN Solution
• Use utterly simple switches that only do routing and access control
• Program all control functionality in logically centralized controller
• Make controller interact with data plane over out-of-band network

But
• Can we solve the problems that SDN is motivated by, with existing network devices and protocols?
How we conceptualize (separated resilient VPNs)

Specification
Synthesis
Diagnosis
Repair
Visualization
Verification
MTD
Emulation
Distribution
Design Intent

Months \(\rightarrow\) minutes

Model and solve dependencies between configuration variables with SMT solvers

Make existing protocols and their compositions do all the work for us

How we implement
Centralized Management over Out of Band Network Using CORE Linux Router Emulator
Specify Secure and Resilient VPNs As Composition of GRE, IPsec and OSPF

Global Specification

gre ipsec tunnel options 192.168.21.0 30
IGW-L-0 Tunnel0 eth0
IGW-C-0 Tunnel0 eth0
1234567890 esp-des esp-md5-hmac

gre ipsec tunnel options 192.168.21.4 30
IGW-L-0 Tunnel1 eth0
IGW-S-0 Tunnel0 eth0
1234567890 esp-des esp-md5-hmac

gre ipsec tunnel options 192.168.21.8 30
IGW-R-0 Tunnel0 eth0
IGW-C-0 Tunnel1 eth0
1234567890 esp-des esp-md5-hmac

gre ipsec tunnel options 192.168.21.12 30
IGW-R-0 Tunnel1 eth0
IGW-S-0 Tunnel1 eth0
1234567890 esp-des esp-md5-hmac

Abstract Solution

gre_local_physical("IGW-L-0",Tunnel0) = '2.1.0.9'
gre_remote_physical("IGW-C-0",Tunnel0) = '2.1.0.9'
gre_remote_physical("IGW-L-0",Tunnel0) = '1.1.0.3'
gre_local_physical("IGW-C-0",Tunnel0) = '1.1.0.3'
ip_address("IGW-L-0",eth0) = '2.1.0.9'
ip_address("IGW-C-0",eth0) = '1.1.0.3'

mask("IGW-L-0",Tunnel0) = 30
mask("IGW-C-0",Tunnel0) = 30

ipsec_ea("IGW-L-0",eth0,'IGW-C-0',eth0) = 'esp-des'
ipsec_ea("IGW-C-0",eth0,'IGW-L-0',eth0) = 'esp-des'
ipsec_ha("IGW-L-0",eth0,'IGW-C-0',eth0) = 'esp-md5-hmac'
ipsec_ha("IGW-C-0",eth0,'IGW-L-0',eth0) = 'esp-md5-hmac'
ipsec_key("IGW-L-0",eth0,'IGW-C-0',eth0) = 1234567890

ipsec_acl_id("IGW-L-0",eth0,'IGW-C-0',eth0) = 'gre_ipsec_IGW-L-0-eth0_IGW-C-0-eth0'
ipsec_acl_id("IGW-C-0",eth0,'IGW-L-0',eth0) = 'gre_ipsec_IGW-C-0-eth0_IGW-L-0-eth0'

ipsec_ea("IGW-L-0",eth0,'IGW-C-0',eth0) = 'esp-des'

Vendor-Specific Configuration

==== IGW-C-0.sh ====

ip tunnel add Tunnel0 mode local 1.1.0.3 remote 2.1.0.9
ttl 225
ifconfig Tunnel0 multicast
ifconfig Tunnel0 192.168.21.1 netmask 255.255.255.252 up
ip tunnel add Tunnel1 mode local 1.1.0.3 remote 3.1.0.17
ttl 225
ifconfig Tunnel1 multicast
ifconfig Tunnel1 192.168.21.10 netmask 255.255.255.252 up
ifconfig eth0 1.1.0.3 netmask 255.255.255.0 up
ifconfig eth1 1.1.100.2 netmask 255.255.255.0 up
ifconfig eth2 172.16.16.12 netmask 255.255.255.0 up

cat >> /usr/local/etc/quagga/Quagga.conf <==HEAR_HEAR
hostname IGW-C-0
password adadc
enable password adadc

tunnel add Tunnel1 mode

ifconfig Tunnel1 192.168.21.10 netmask 255.255.255.252 up
ifconfig eth0 1.1.0.3 netmask 255.255.255.0 up
ifconfig eth1 1.1.100.2 netmask 255.255.255.0 up
ifconfig eth2 172.16.16.12 netmask 255.255.255.0 up

cat >> /usr/local/etc/quagga/daemons <==HEAR_HEAR
zebra=yes
ospfd=yes
HEAR_HEAR

service quagga restart
iptables -A INPUT -j ACCEPT -s 1.1.0.3/32 -d 2.1.0.9/32
iptables -A INPUT -j ACCEPT -s 1.1.0.3/32 -d 3.1.0.17/32
PCONF= mktemp --tmpdir psk.XXXXXX
Successful Ping:
Client-R-0 to Server-L-0
Router-IGW-C-0 Goes Down:
OSPF establishes alternate routes through IGW-S-0
Distributed Control

For global consistency, use determinism of SMT solvers and total message ordering of group communication protocols.

Controllers Collaborate Over Logical CAP Message Bus
Controllers Configure Devices In Their Enclave With No Out-of-Band Network
Successful Ping:
Client-R-0 to Server-L-0
Devise an ILP-based symbolic encoding of the network and use it to model how packets are forwarded by routers before and after they are configured.

Encode constraints that will ensure a safe reconfiguration order.