TURNING
INTO REALITY

Revisiting Routing Control Platforms with the Eyes and Muscles of Software-Defined Networking

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Agenda

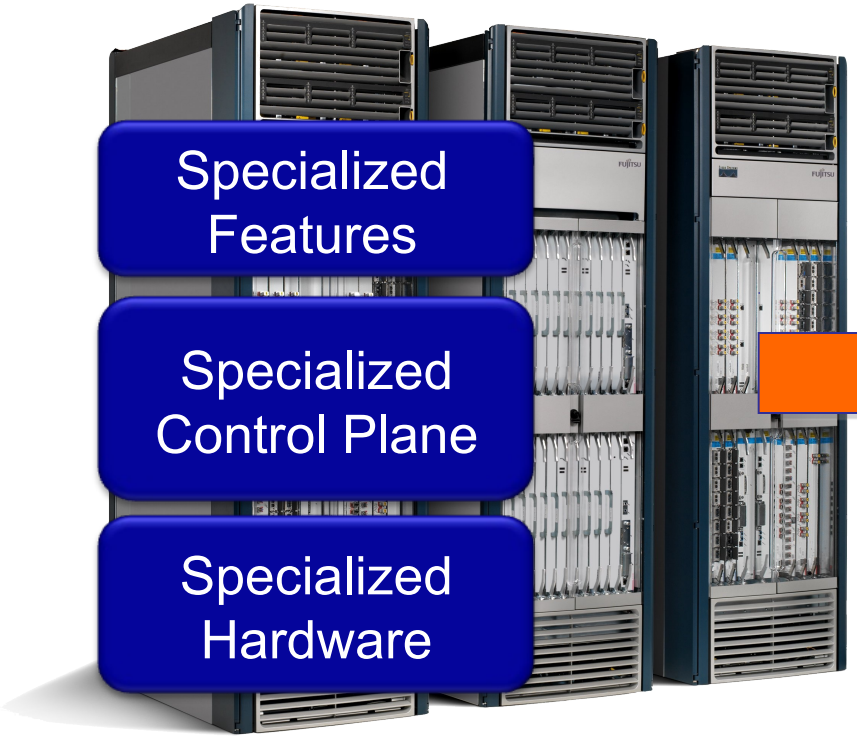
- Research in scope and contribution
- RouteFlow Control Platform
  - Multi-controller architecture
  - Proof of concept implementation: Single node abstract eBGP router
- Use Cases
- Challenges
- Conclusions and Future Work

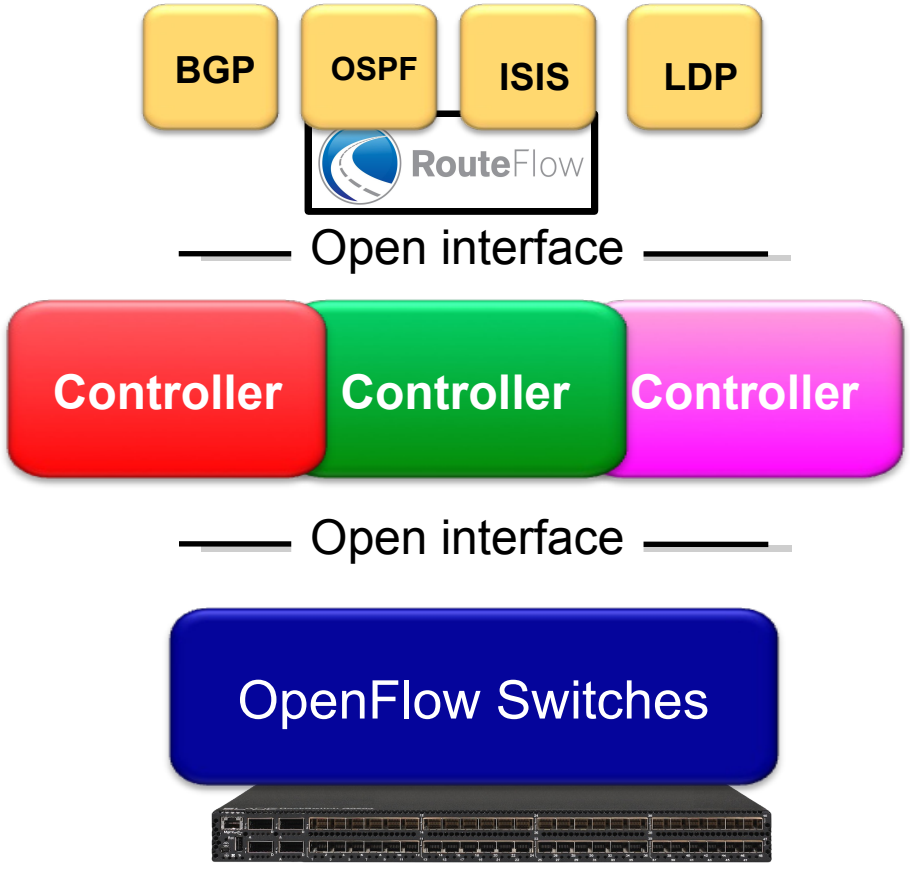
Research in scope and contribution

- Early work on Routing Control Platforms (RCP)
  [Ramjee 2006, Feamster 2004, Van der Merwe 2006, Wang 2009]
  - In operation at AT&T, considered a differentiator for "dynamic connectivity management".
- Research Question:
  - Re-examine the concept of RCP with the visibility
    (i.e., network-wide, multi-layer, flow and topology maps, full RIBs
    and direct control capabilities
    (i.e., actual FIB installation, rich matching and instruction set)
    of the SDN abstraction set and the specifics of the OpenFlow choice

- RouteFlow glues virtualized IP routing stacks with OpenFlow
- RouteFlow acts as a new indirection layer for
  - routing protocol messages (e.g. BGP session terminates in servers)
  - RIB-(to-FIB)-to-OpenFlow transformations

Software Defined IP Routing



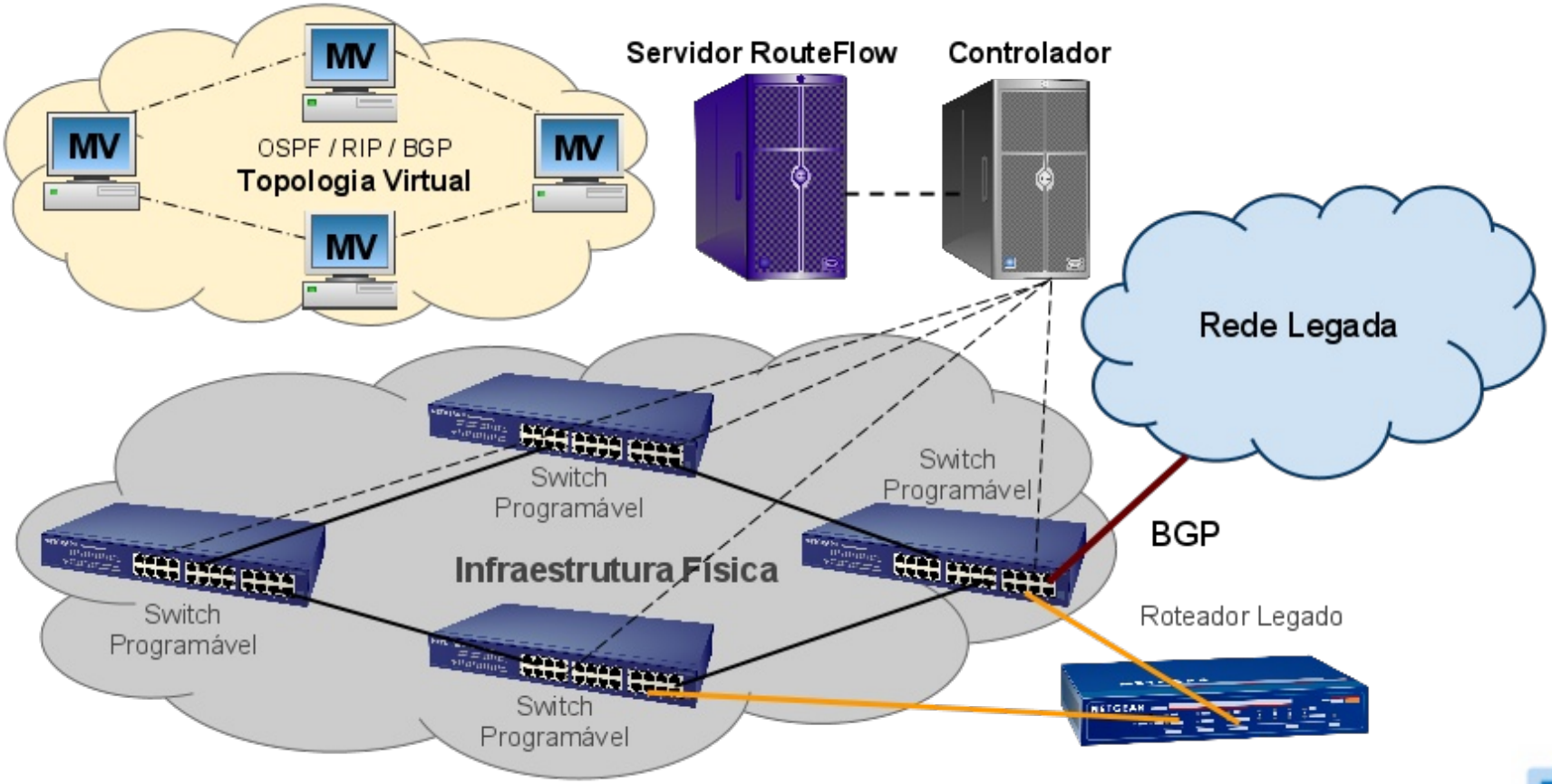


High cost
Specialized config.
Closed source
Slow innovation

Source: McKeown

Low cost (commodity)
Multi-vendor modularity
Open source
Rapid innovation

RouteFlow



GIGA
REDE EXPERIMENTAL DE ALTA VELOCIDADE

FINEP

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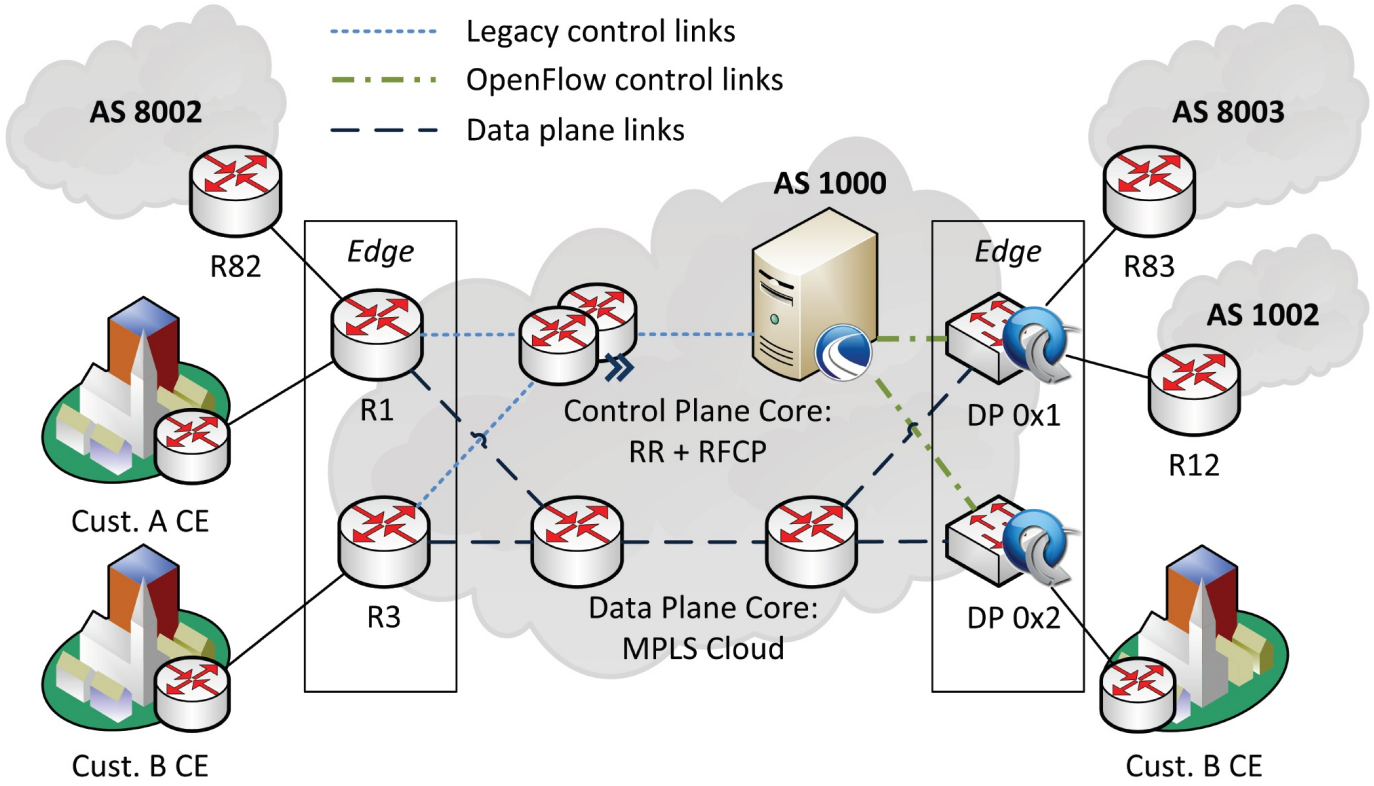
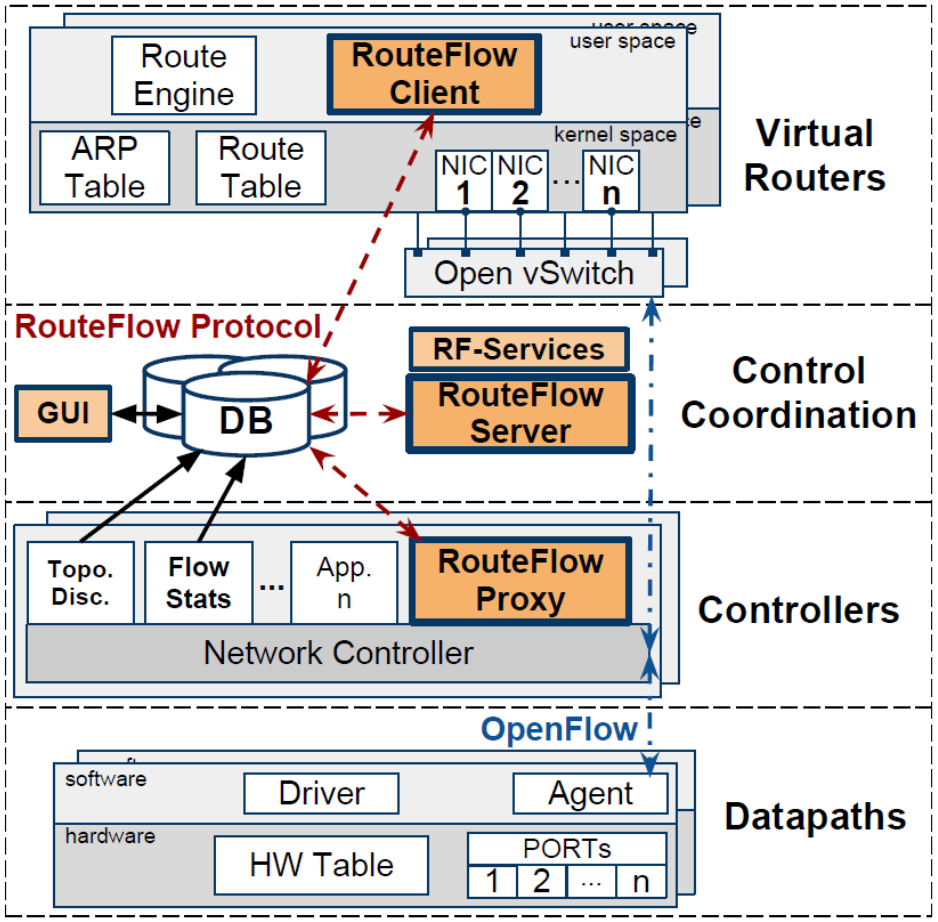
Controller-Centric Hybrid Networking

- A migration path to roll out OpenFlow technology
- Not a revolution, but an evolution of current iBGP RRs to essentially eBGP Route Controllers
  - "BGP-free edge": A cost-effective simplified edge for SW-driven innovations



Design

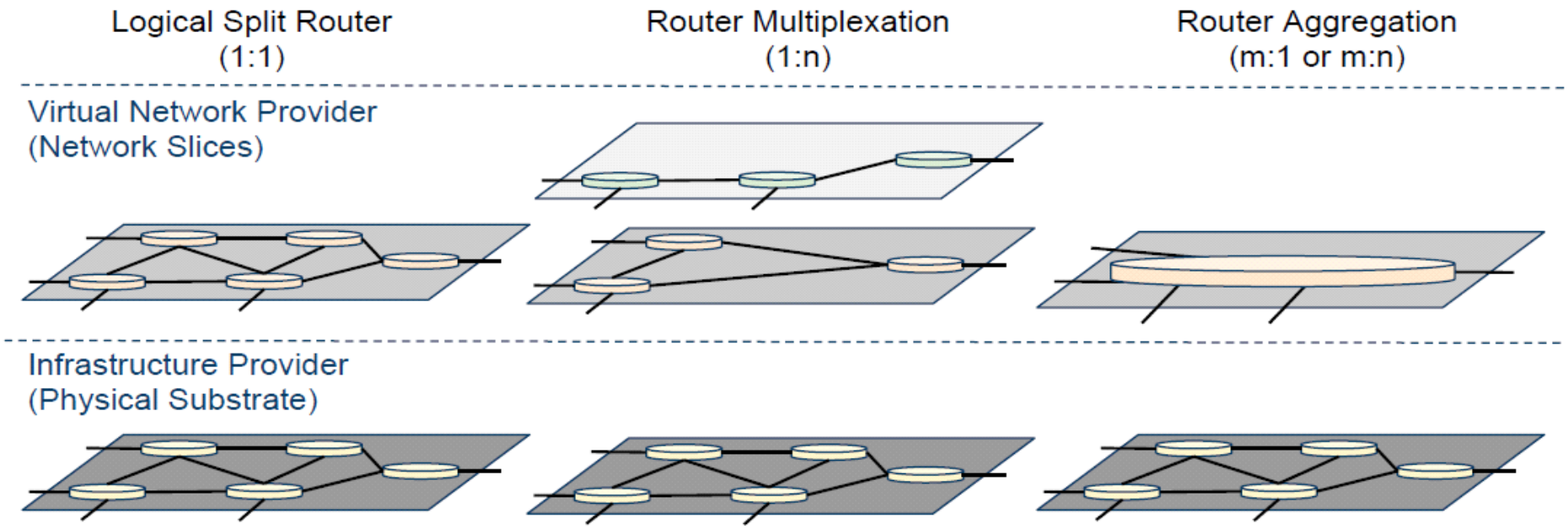


Key Features

- Modular architecture
  - RF-Proxy
  - RF-Server
  - RF-Client
- Database layer
  - JSON-based IPC
  - Resillient core state
  - Programmer-friendly
- Multi-Controller support
  - NOX, POX, (Ryu)
  - Floodlight, Trema (planned)

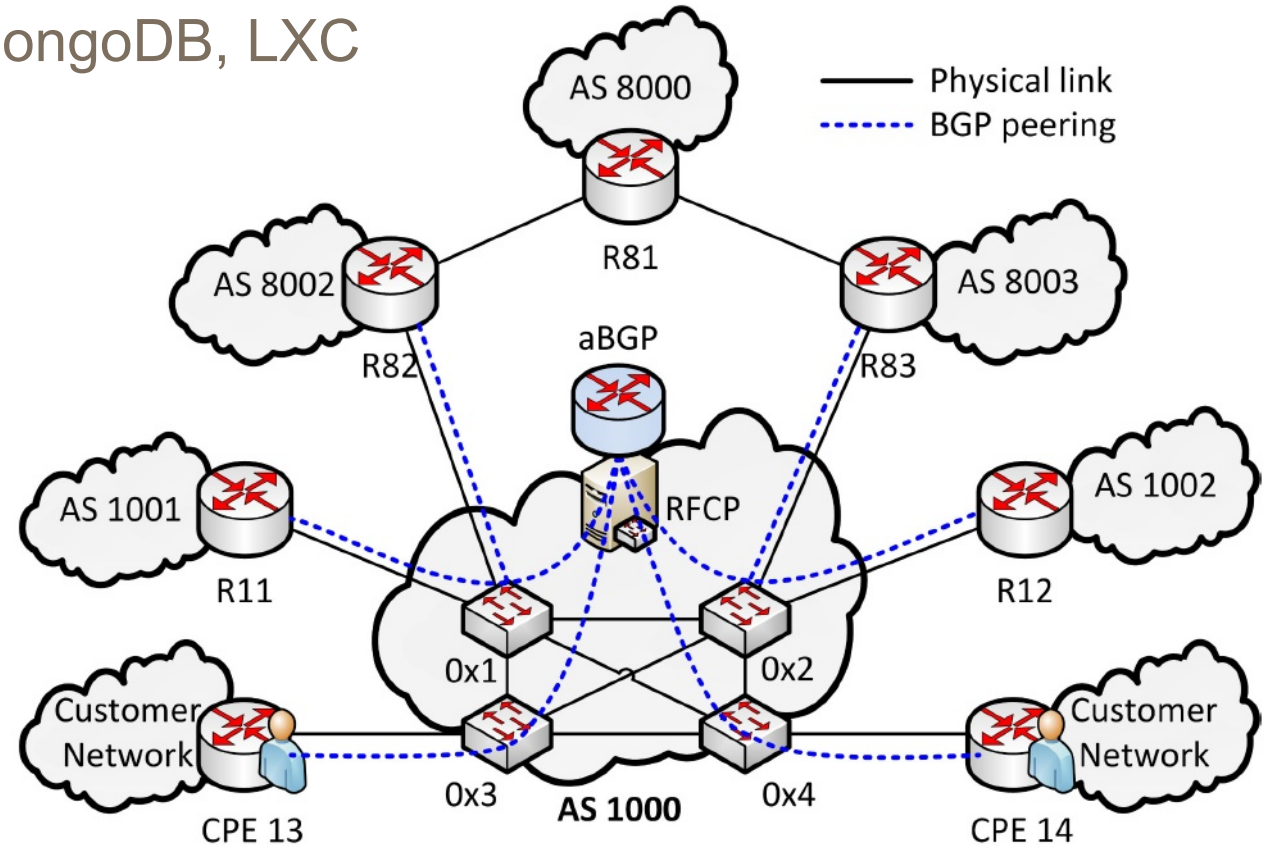
Modes of operation

- From logical routers (akin VRFs) to single node abstractions over flexible virtual networks.
- New design choices on the distribution of the control nodes.



Aggregated BGP routing service

- Single node abstraction of a domain-wide eBGP router
  - Think modern multi-chasis routing architectures with external route processors and OpenFlow switches acting as line cards
- Aggregation logic defined in the RF-Server
- NOX, MongoDB, LXC



Routing-centric use cases under research

- Engineered path selection
  - Think Google WAN, performance-based routing, etc.
- Optimal best path reflection
  - Per ingress/customer [draft-ietf-idr-bgp-optimal-route-reflection-01]
- Path protection with prefix independent convergence
  - Hierarchical FIBs w/ OF 1.X Tables + LFA route-precomputation
- Security
  - Data plane blackholes and middlebox injections,
  - Secure Inter-domain routing ideas (crypto intense S*-BGP, etc..)
- Simplifying customer multi-homing
  - Easy to set and control cost/performance/policy-based routing
- IPv6 migration
  - Flow matching for service termination in v4-v6 migration solutions

Challenges

- Centralized BGP
  - Shown to scale well in modern CPU architectures
  - Centralized does not mean not disitrbuted (but removal from edge)
- Small OpenFlow table sizes
  - Transient limitation?
  - Expose existing FIB data structures as an IP lookup OF table?
  - Smart RIB&FIB reduction (e.g., simple [draft-ietf-grow-simple-va-04]
  - HW/SW flow offloading
- Limited OpenFlow processing in datapath
  - Transient / Un-optimized implementations
- High availability
  - Previous ideas from disitributed RCPs
  - Database-centric designs
  - Development in-progress of “BGP SHIM” for transparent eBGP redundancy

Conclusions

- RouteFlow is
  - a simple yet powerful (adaptable, inexpensive) routing architecture
  - a platform for real IP routing protocol experimentation
  - a tool for OpenFlow adoption via controller-centric hybrid networking
- Many open research questions and future work
  - OF 1.X, MPLS, OAM, GUI, policy languages, configuration mgm, etc.
- Opportunity for a community-driven development of competitive, deployable, open routing control solutions

RouteFlow

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Evolving the IP routing landscape with OpenFlow/SDN

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Thank you!

Questions?

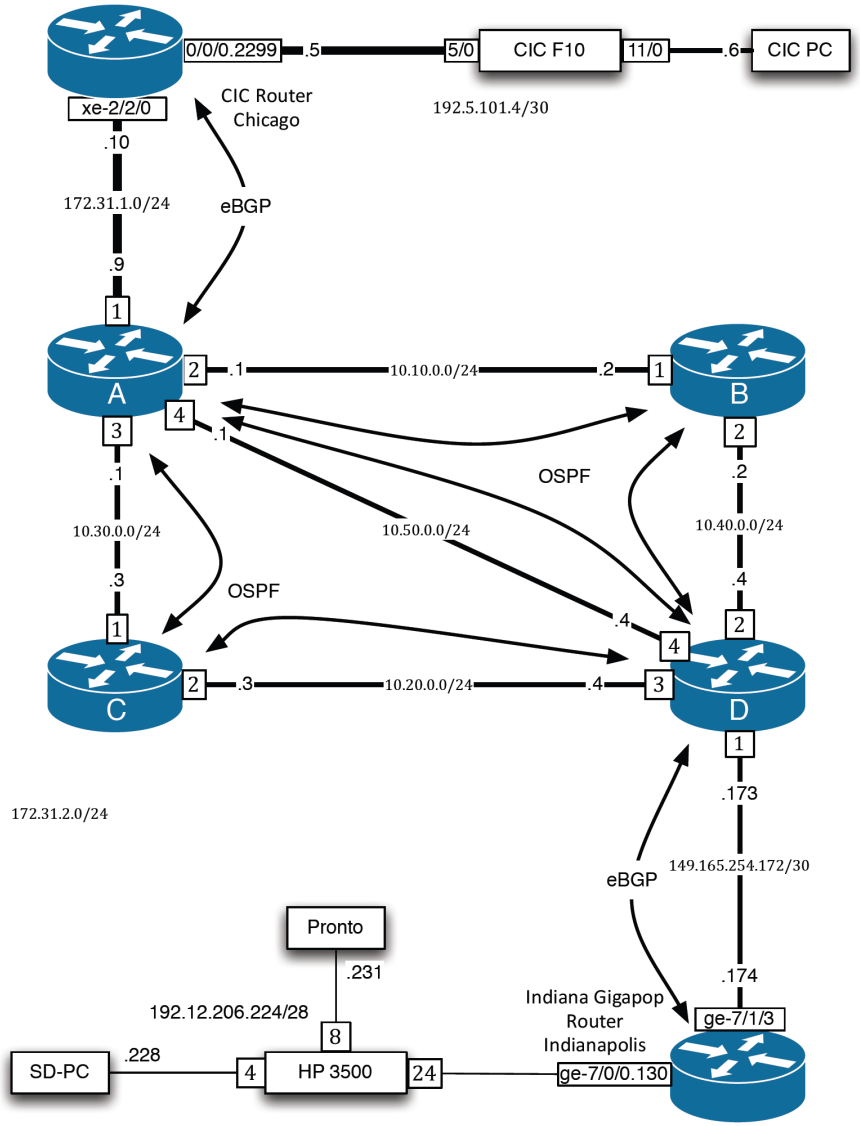
Live DEMO

- Access:
  - http://go.cpqd.com.br/7API-demo

- Indiana University GUI demo:
  - http://goo.gl/T3Tqe

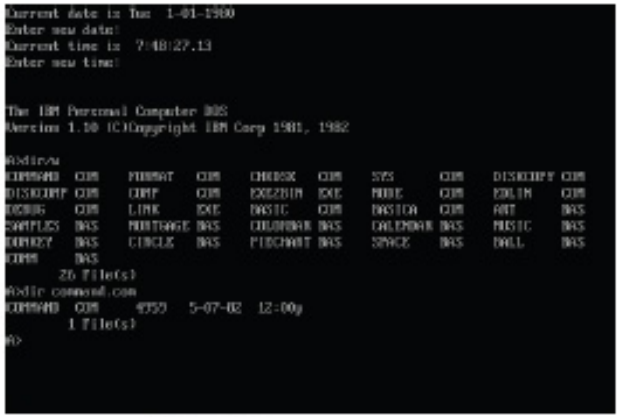
InCNTRE Deployment

- 4 Virtual routers
- 10 Gig and 1 Gig connections
- 2 BGP connections to external networks
- Remote Controller
- New User Interface

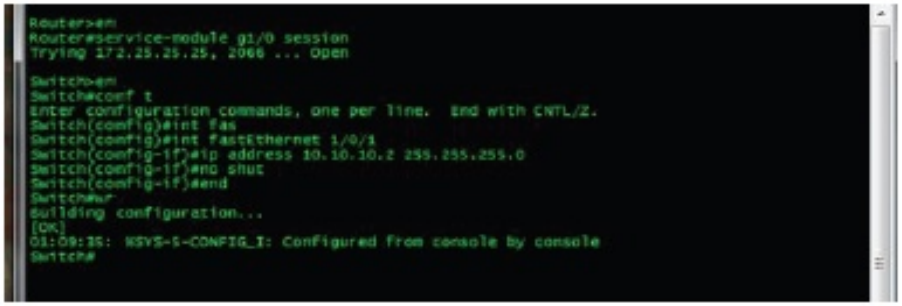


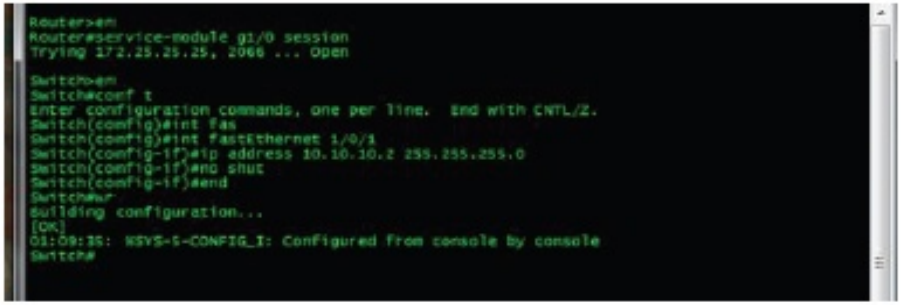
Compare interfaces over the last 30 years

"PC" user interfaces



Network user interfaces





Source: Chris Small (Indiana)

Demystifying Configuation Challenges and Tradoffs in Network Based ISP Services (Benson, Akella,Shaikh SIGCOMM 2011)

RouteFlow User Interface

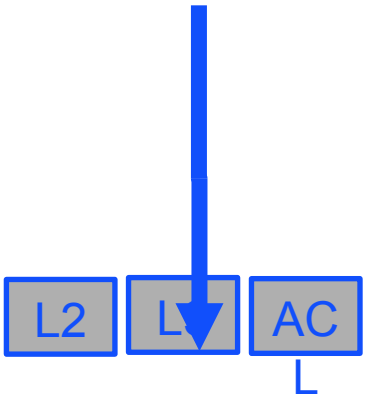
- How to make network administration:
  - Simpler to implement
  - More robust and consistent
  - Easier to manage
- Automation and Abstraction
- Can you build very different interfaces with SDN backends?

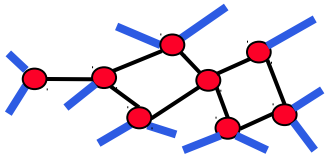
E.g., type: http://netkarma.testlab.grnoc.iu.edu/rf/ or... http://goo.gl/T3Tqe

Source: Chris Small (Indiana)

RouteFlow Platform research topics

- High availability
- Integration of OF v1.1, v1.2 and v1.3
- LDP / MPLS support towards open-source LSR
- Realizing the northbound SDN abstractions
  - Specification / Configuration
  - Network Information Base
  - Knowledge Information Base
- Troubleshooting, testing, debugging, ...
- ...





Collaborations and community developments

- Web-based UI & Internet 2 HW pilot [C. Small, Indiana] ✔
- Aggregated BGP Routing Service [C. Corrêa, Unirio] ✔
- SNMP plugin [J. Stringer, Google] ✔

- Optimal BGP best path reflection [R. Raszuk, NTT-MCL] ◷
- OpenFlow v1.1 and v1.2 [w/ Ericsson] ◶
- Open Label Switched Router [OSRF; Google] ◵

- Multi-path, Fast-ReRoute, BGP-Sec, IPv6, ... [YOU?] ?

RouteFlow

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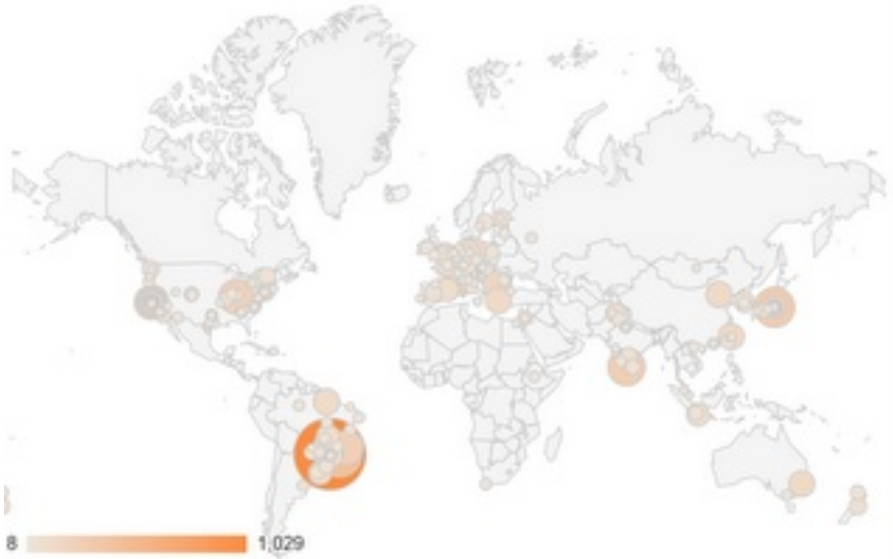
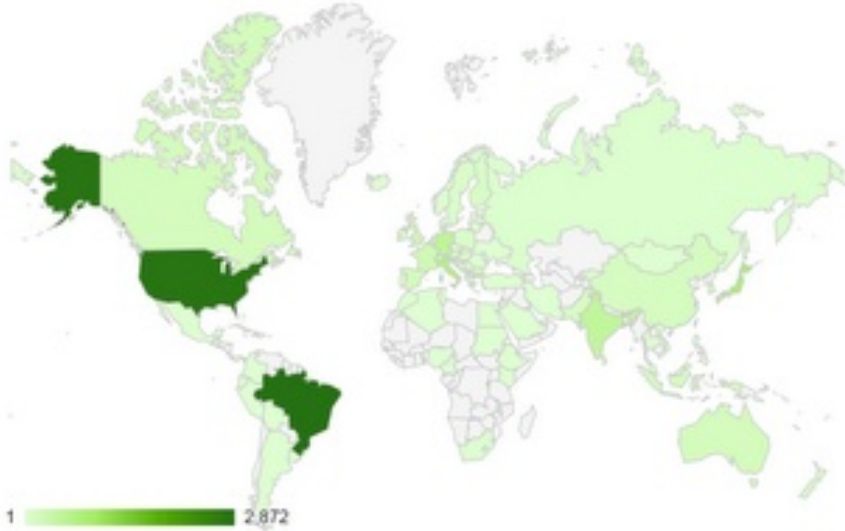
… building a community

Visits: 12,000+ (5,000+ Unique)

From over 1,100 cities of 90+ countries all over the globe!





http://go.cpqd.com.br/routeflow/

RouteFlow

368

days since
Project Launch

GIGA
REDE EXPERIMENTAL DE ALTA VELOCIDADE

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github SOCIAL CODING

Apache

Conclusions

- RouteFlow is
  - a simple yet powerful (adaptable, inexpensive) router design
  - a platform for real routing protocol experimentation
  - a tool for OpenFlow adoption via controller-centric hybrid networking
- Many open research questions
- Experimental research facilities are critical for validation
- Opportunity for a community-driven development of competitive, deployable, open routing control solutions

RouteFlow

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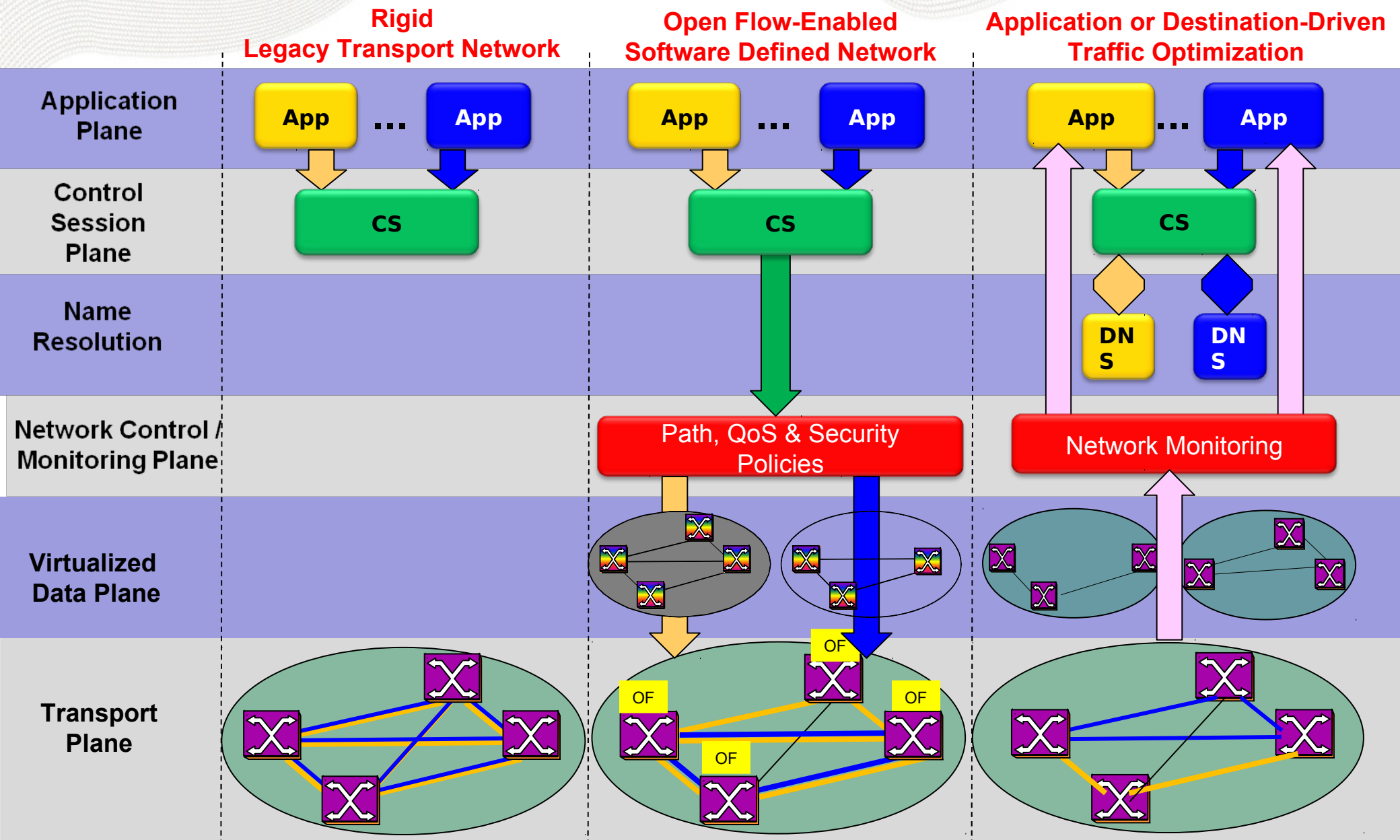
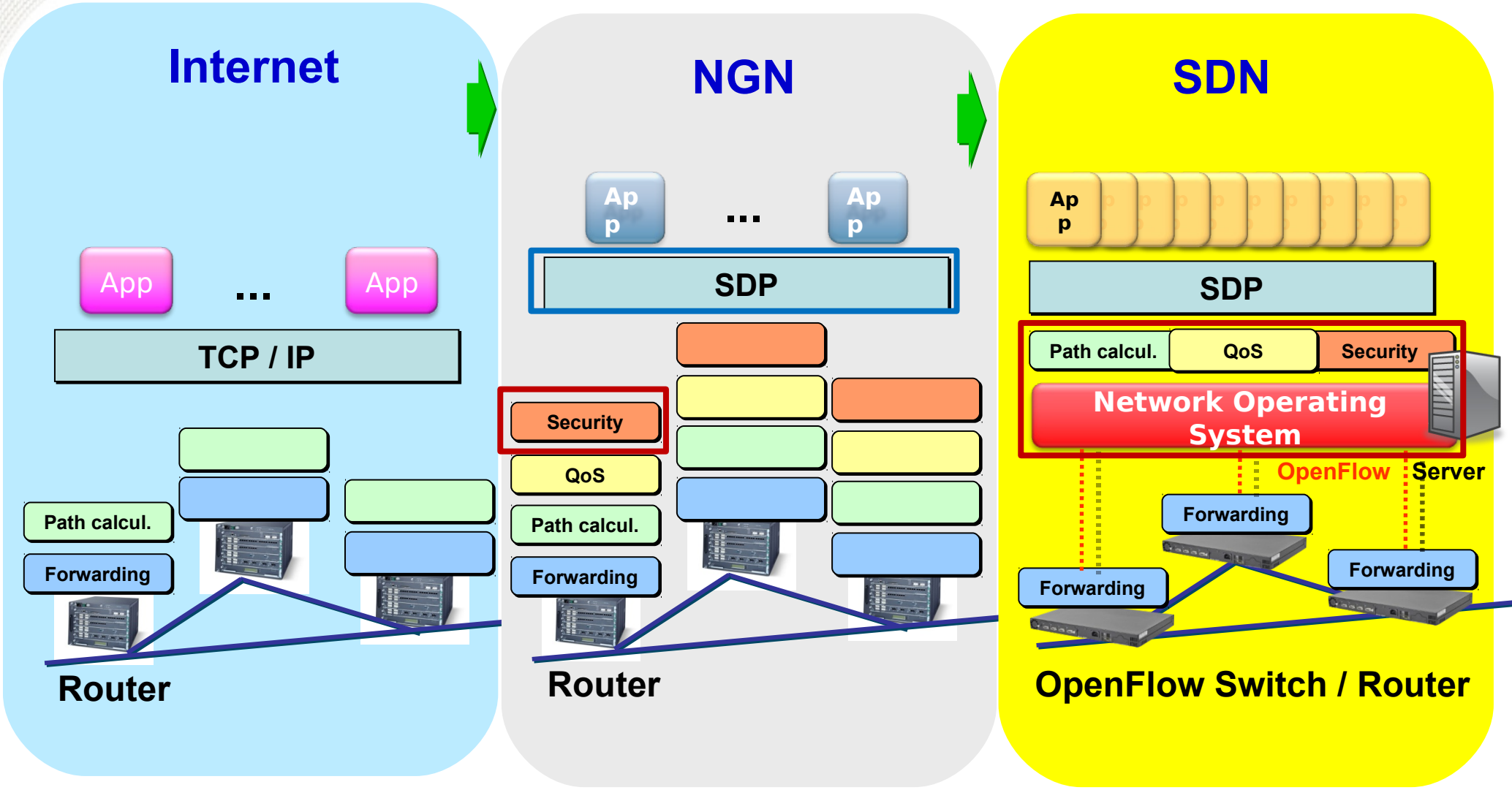
Beneficios e impactos

- Inovação tecnológica em soluções de redes e serviços para os proprietários de infra-estrutura, os provedores de serviços e a comunidade de pesquisa.
- Oportunidade para que empresas nacionais possam competir e inovar na área de aplicações para gerenciamento e controle de redes de pacotes.
- Novos modelos de negócio que promovem redução de CAPEX e OPEX por meio de novos serviços (ex. alocação dinâmica de fatias/recursos da rede), reaproveitamento de ativos e automatização dos processos operacionais.
- Diminuição do tempo ao mercado na implementação de funcionalidades e soluções de redes integradas e customizadas à demanda do cliente.
- Simplificação e barateamento dos equipamentos pela diminuição dos requisitos mínimos de SW embarcado e pilhas de protocolos proprietárias.
- Consolidação dos planos de controle e gerência de infra-estruturas de rede, facilitando a convergência ampla e a migração para novos padrões e tecnologias de rede de transporte.

SDN Converged Network Services

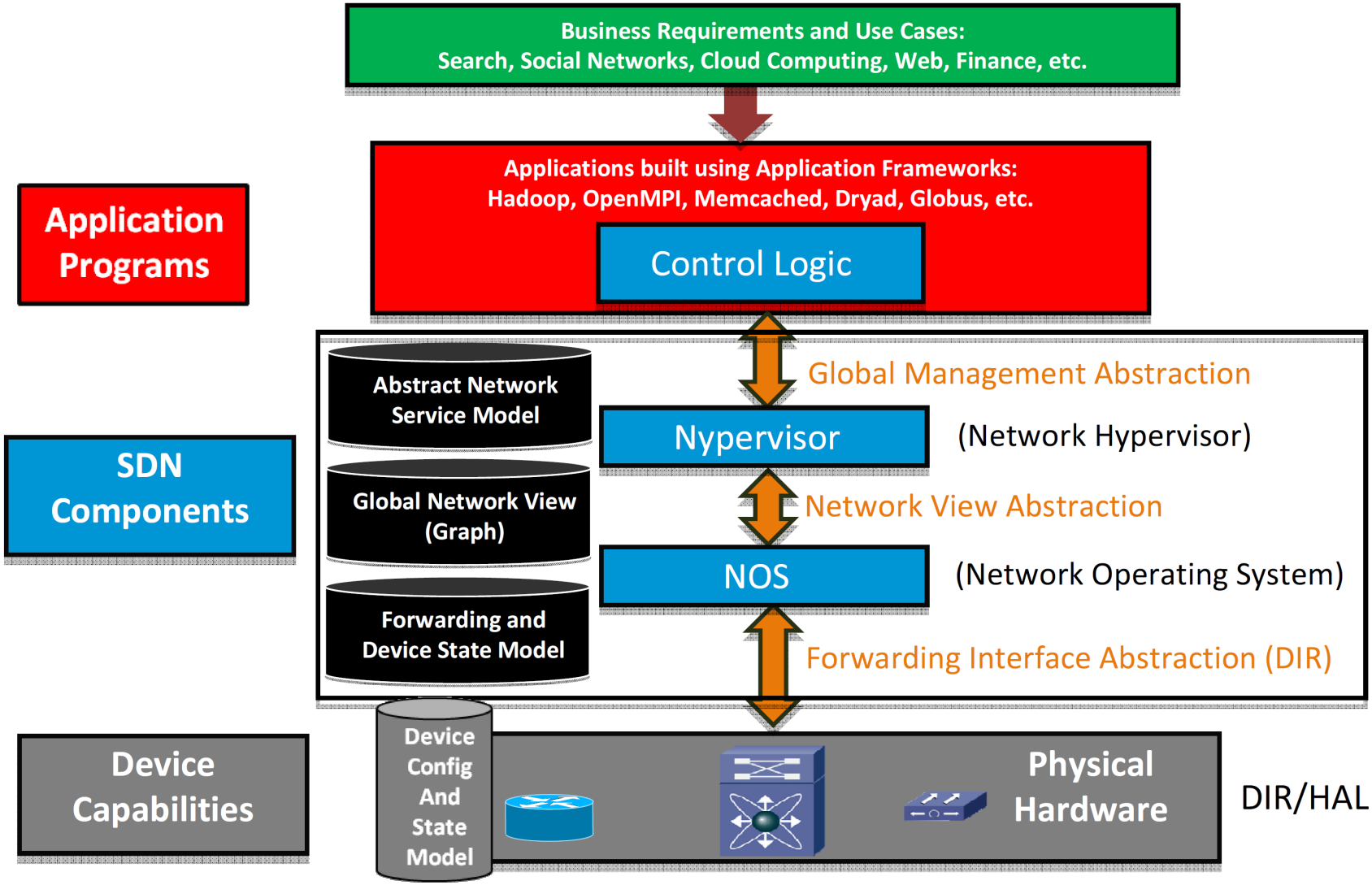


Rede Convergente Definida por Software (RCDS)

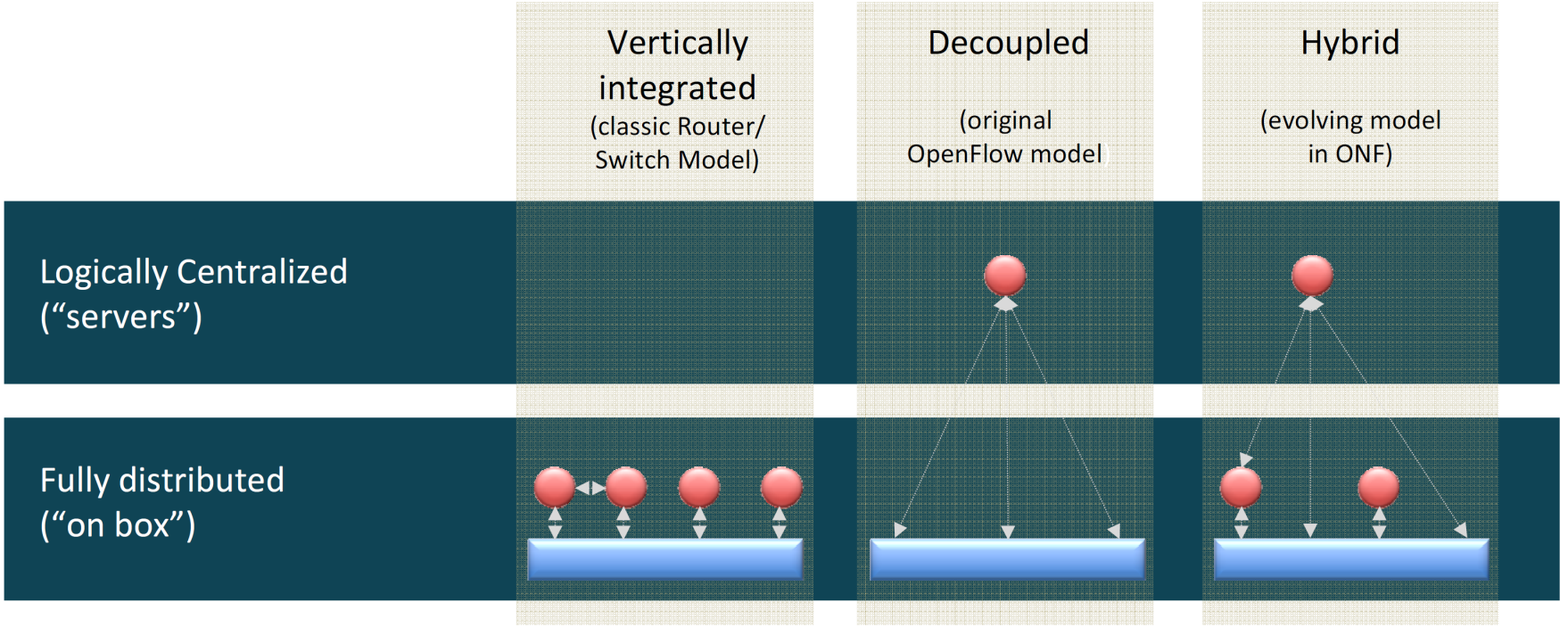


Source: NEC, adapted

“Modern” OF/SDN architecture



Control Plane Distribution Options



Data Path jointly controlled by standard on-box control plane and centralized off-box controller

Slide courtesy Frank Brockners