

# Towards a Predictive Internet

01-NOV-2021 JP Vasseur - Cisco Systems



## Imagine a world (only) reacting with no learning?



#### Networking ...

## Network recovery has been reactive for 25 years...

- Protection/Restoration
- Relies of fast detection of failure, followed by rerouting
- Fast OSPF, IS-IS, BGP-PIC, MPLS FRR,

IP FRR, multi-layer recovery, ...

#### Still no learning ...



#### The Human Brain ...

- · Learning thanks to experience
- Role of memory in anticipation in PreFrontal Cortex (PFC)
- Planning is about Forecasting ...



#### The Networking Brain

#### Learning ... capable of:

- Direct application feed-back (yes)
- Build a model of (Internet) world (network & application)
- Predict a (with some error) & Automate
- Constantly adapts via learning ...

## **Objectives of a Predictive Internet**



The Predictive Internet is about:

Use of **Predictive** approach (combined with Reactive)

Application Experience (Dark & Grey Failures)

(Trusted) Automation (Self Healing networks)

## A Predictive Internet with Edge Control point





#### **Dynamics of Latency**



#### **Seasonal Peak Time of Day**



#### US-Argentina (SP-3/Florida to SP-4/Buenos Aires US-US England-Texas US-India (SP-1/NJ to SP-2/California) (SP--5/England to SP-6/Texas) (SP-6/Texas to SP-7/Bangalore/India) Highly varying latencies (from 100 ms to 250 ms) Tunnels either have · Most tunnels have tight Most tunnels have latency distributions (low variance) mean ~125ms or ~250 ms similar mean latencies Latency has Tunnels with larger latencies have higher Tunnels with mean ~250ms have high variance Mean latencies high variance are similar variance X 200 200 Latency in ma US-US High loss across US-US US-US (Low loss) US-India (High loss) customers High Loss for one customer (SP1/Texas to SP2/California (SP1/Texas to SP2/India) (SP4/NJ to SP5/California) 4/New Jersey to SP6/Mass Customer-2 Customer-1 Customer-3 Customer-4 Customer-5 Customer-3 - Customer-4 5 customers have moderate loss One customer Each customer has Small portion of paths (Customer-2) specific pattern of loss High mean losses have high loss has high loss 4 6 Loss Percentage Loss Percentag

#### **Dynamics of Latency and Loss**

### **Voice Quality (User Experience Score) Variability**

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Percentage of Reports where **UES < 4** 









### **Results**

## Conclusion

## Enabling Learning in the Internet is overdue (Predict)

Need to extend the notion of Dark failure (lack of connectivity) to Grey failure with application impact

The Internet stack concept of layering (IP hourglass model did allow for scaling. With an application centric view, cross-layer signaling is useful

More results, white papers in-progress ...



# Thank you

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