SDN for Wildfire Response

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SDN for Disaster Relief Networks

- Lots of research on individual components, little on integration.
- SDN holds lots of promise for efficient, resilient networks.
- Current mobile networks don’t fit requirements of disaster workers.

Motivating Example - Wildfires

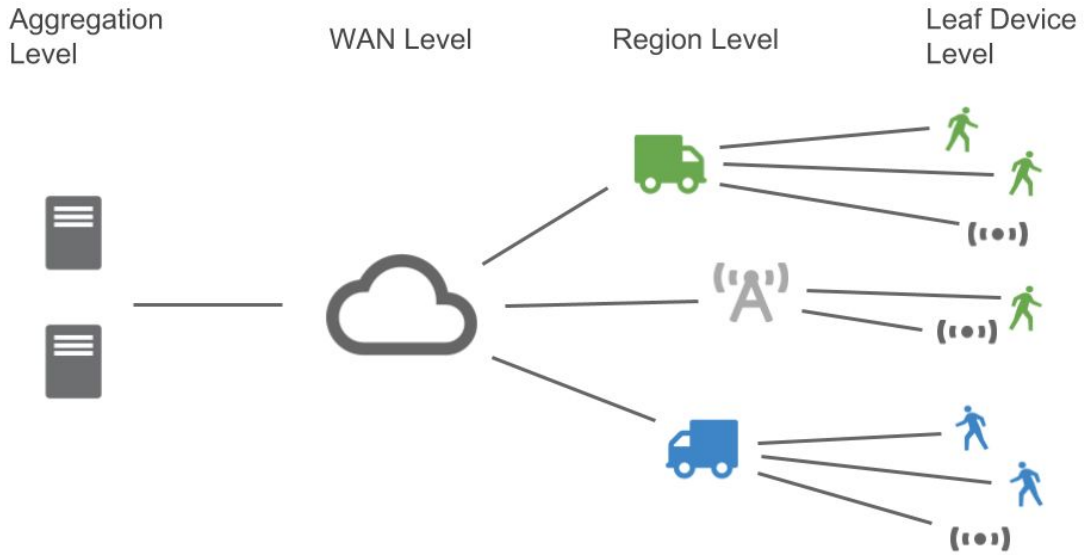
- NIFC reported more than 70k wildfires in the US in 2017 which burned a total of more than 10 million acres[1].
- 14 direct wildfire-caused deaths in the US in 2017[2].
- $2 billion spent fighting wildfires in 2017[3].
- Need for integrated communications and data networks.

[1] National Interagency Fire Center. 2017. 2017 Wildfires Reported to NICC. Available at https://www.predictiveservices.nifc.gov/intelligence/2017_statssumm/wildfire_charts_tables17.pdf (2018/12/2).

[2] National Interagency Fire Center. 2017. Fatalities by Year. Available at https://www.nifc.gov/safety/safety_documents/Fatalities-by-Year.pdf (2018/12/2).

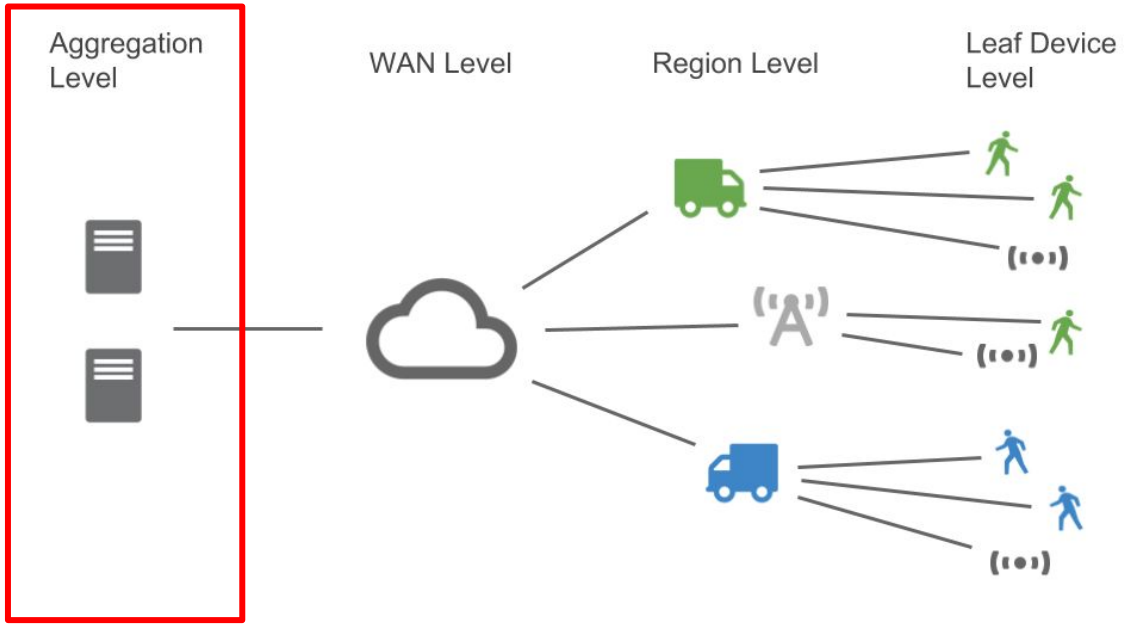
[3] Laura Zuckerman. 2017. Cost of fighting U.S. wildfires topped $2 billion in 2017. Available at https://www.reuters.com/article/us-usa-wildfires/cost-of-fighting-u-s-wildfires-topped-2-billion-in-2017-idUSKCN1BQ01F (2018/12/2).

Network Example



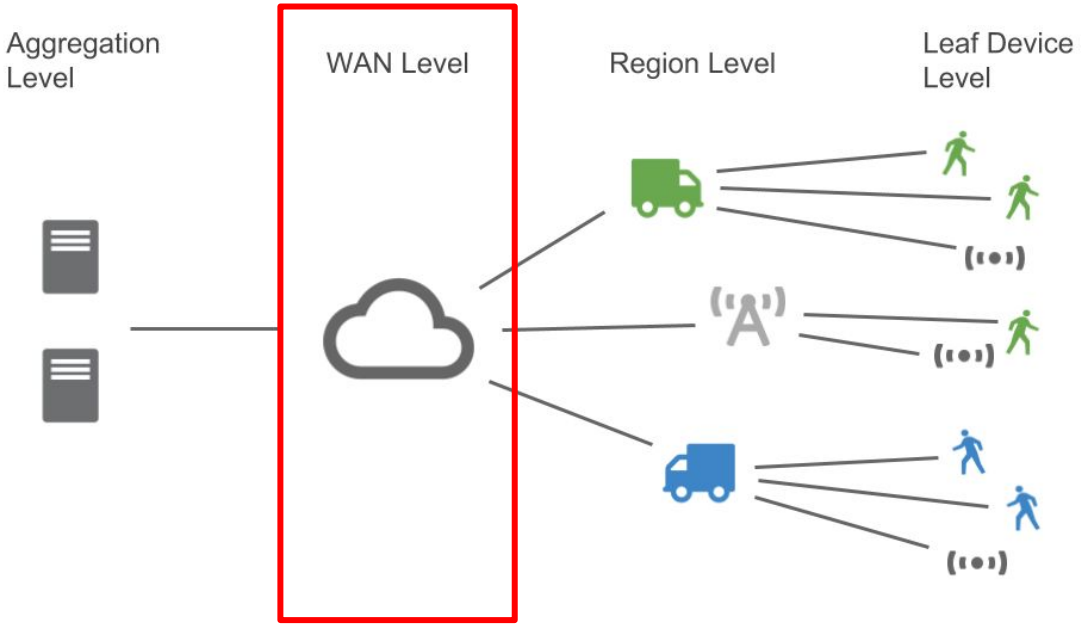
Network Requirements - Aggregation

- Computation power, storage
- Reliable links to lower levels
- Ability to control rest of network



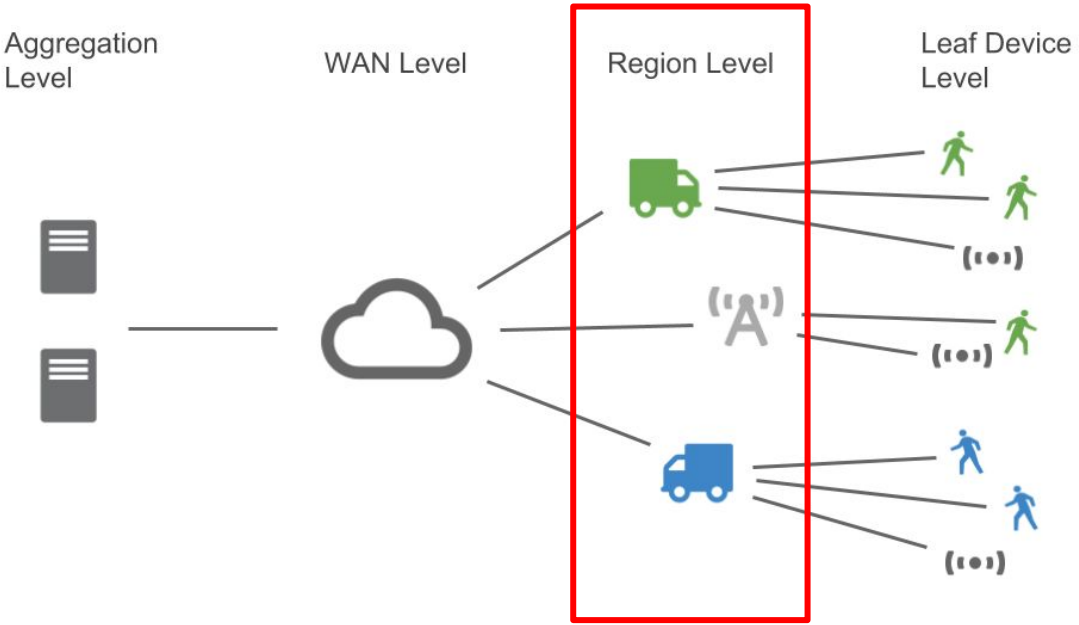
Network Requirements - WAN

- Resilience to damage
- Optimal routing



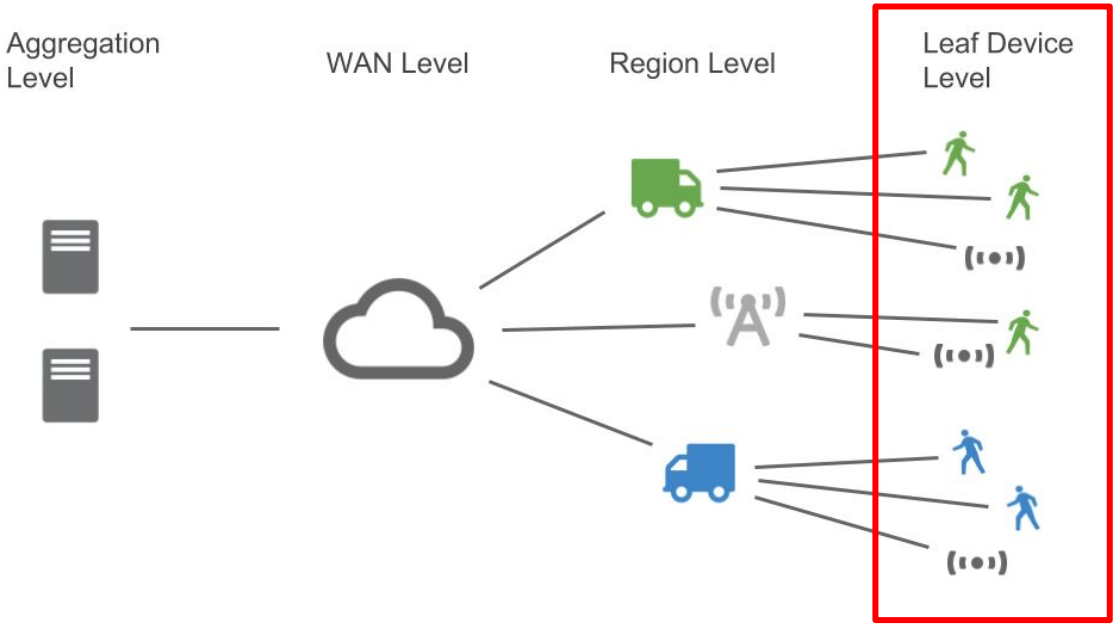
Network Requirements - Region

- Scalability
- Ability to respond to failures and partitions
- Connectivity to aggregation level



Network Requirements - Leaf Devices

- Connectivity to other leaf level devices
- High mobility
- High efficiency
- Delivery / QoS guarantees

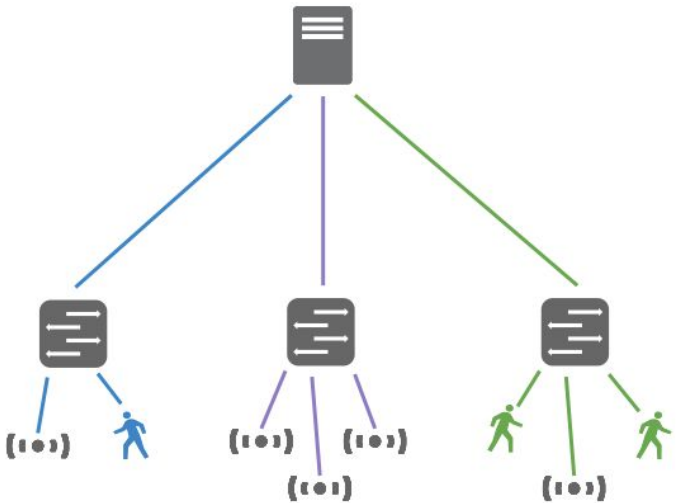


SDN Design Considerations

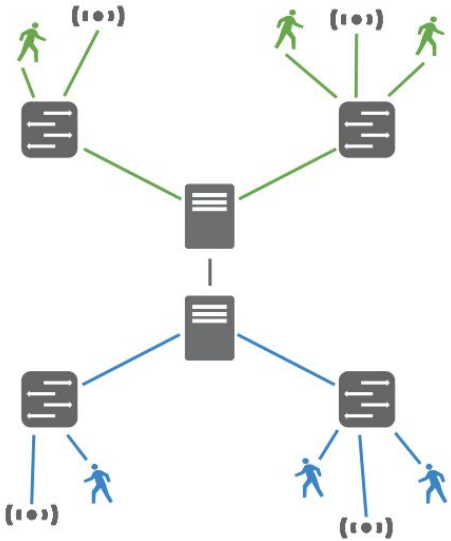
- Controller architecture
- Routing policies
- Resilience methods

Controller Architecture

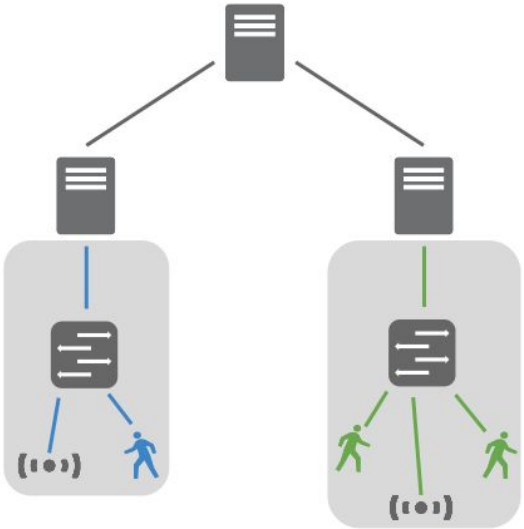
Centralized



Distributed
(Partitioned)

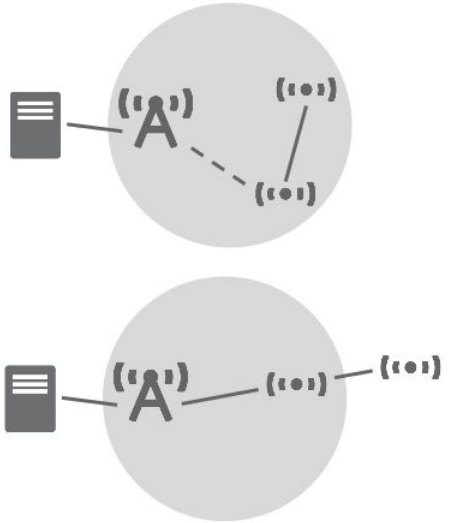


Distributed
(Aggregated)



Routing Policies

- Delivery, QoS
- Load balancing
- Increased range
- D2D links
- Software defined mobile ad hoc networks



Resilience Methods

- Reactive
  - On-demand recomputation
- Proactive
  - Fast-failover groups
  - Header-embedded backup paths
- Alternate
  - Secondary connections
  - D2D links
  - Message ferrying

Integration

- Putting everything together...
  - Distributed, flexible, scalable control
  - Routing policies that prioritize communications with QoS guarantees
  - Highly resistant to damage and partitioning

Testing

- Effectiveness
- Efficiency
- Resilience

Testing - Effectiveness

- Are requirements being met for all flow types?
  - QoS / delivery
  - Network failures
  - Geographical variation
- Have we selected the proper routing processes?

Testing - Efficiency

- Are the controllers managing the load?
  - CPU utilization
  - Bandwidth for control measurements
    - In-band vs. out-of-band
  - Time to establish routes for new flows
- Have we selected the best controller architecture and placement?

Testing - Resilience

- Does the network respond well to failure?
  - Single link failures
  - Regional failures
  - Permanent partitions
- This should be tested along with effectiveness and efficiency.

Related Applications

- Other disasters
- Tactical networks
- Smart cities
- Data centers / WAN

Future Applications

- Private networking
- Smart vehicular ad hoc networks
- Ultra-low maintenance networks

Questions?