Experimenting with SDN-based Adaptable Non-IP Protocol Stacks in Smart-City Environments (REWIRE)

GOALS

REWIRE tackles scalability and reliability issues in Smart-Cities through an SDN-based management platform that mixes and matches, on-demand, multiple Non-IP protocol strategies with real (i) rapidly-detected network conditions, and (ii) IoT data communication patterns.

We experiment with:

- Wireless Mesh Network (WNM) deployments over Fed4FIRE+ facilities.
- Autonomous deployment of containerized Non-IP protocol stacks.
- Change-point analysis & clustering mechanisms for unreliable link detection.
- Realistic IoT application traffic patterns based on data from SmartSantander.

CHALLENGES

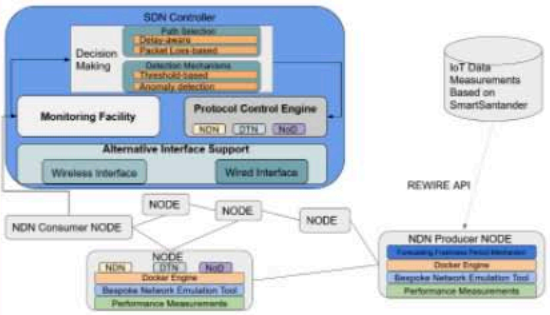
Internet of Things (IoT) technologies:

- are typically associated with critical performance requirements, such as low-delay,
- usually encompass Wireless Mesh Networks.

Main challenges in Smart-Cities wireless outdoor environments:

- consist of numerous & heterogeneous IoT devices,
- network traffic is not always smooth and manageable,
- face connectivity issues (e.g., link failures, no line-of-sight, signal interference).

Architecture



Experimental Methodology

Our novel experimental design facilitates multi-hop mesh networking enabling realistic Smart-City based experimentation, by using the w-iLab.t and CityLab Fed4FIRE+ test-beds. We assess the:

- flexibility and adaptability capabilities of our system - ***w-iLab.1 test-bed*** (*figure 1*),
- impact of adopting multiple Non-IP protocol strategies to handle unreliable connectivity conditions - ***CityLab test-bed*** (*figure 2*),
- identification of scalability and reliability communication issues using statistical-based machine learning (ML) mechanisms - ***CityLab test-bed*** (*figure 3*),
- employment of forecasting mechanisms for the freshness period of IoT measurements - ***SmartSantander test-bed*** *(figure 4).*

RESULTS

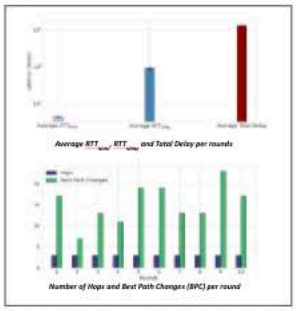


Figure 1. Flexibility and adaptability capabilities

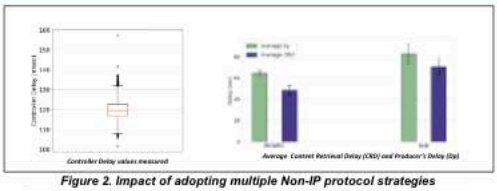


Figure 2. Impact of adopting multiple Non-IP protocol strategies

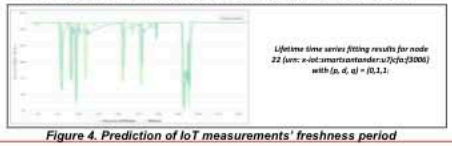


Figure 4. Prediction of IoT measurements' freshness period

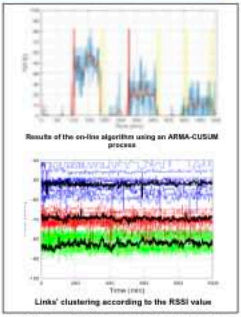


Figure 3. Identification of link reliability issues

CONCLUSIONS

- Our SDN-based approach effectively supports the NDN operation in unstable topologies with frequent dynamic changes, such as the WMNs.
- The adaptive Non-IP protocol deployment mitigates unreliable connectivity conditions in Smart-City environments.
- The multi-protocol SDN controller successfully alternates on-demand the Non-IP protocol stacks, enabling the efficient operation of Smart-City networks that face unreliable communication issues.
- A real-time link-quality detector combining RSSI and PLR is an effective strategy for rapid-detection of unreliable network conditions.
- The IoT measurements freshness period could be efficiently modeled with statistical-based mechanisms.

NEXT STEPS

- Experiments with large-scale scenarios exploiting the unique test-bed federation capabilities of Fed4FIRE+ test-beds.
- Extensions of the Controller capabilities improving its decision making, taking into account additional NDN-related features.
- Investigate relevant research contexts, including: (i) Space and the Non-terrestrial-Networks; (ii) industrial IoTs; and (iii) content-centric networks.
- Introduce a new link-quality detector based on multi-dimensional time-series, matching the dynamics of link quality metrics better.