Processing ANN Traffic Predictions for RAN Energy Efficiency

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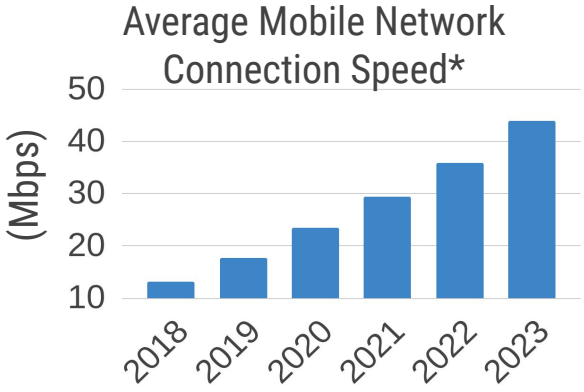
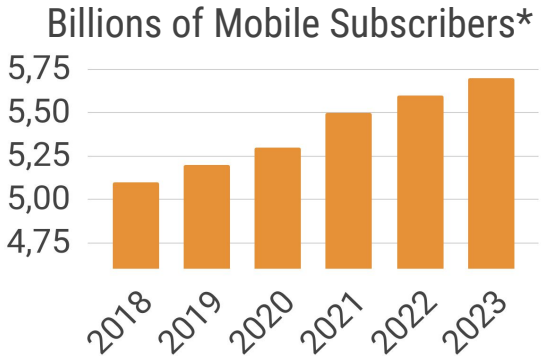
Need for RAN Management

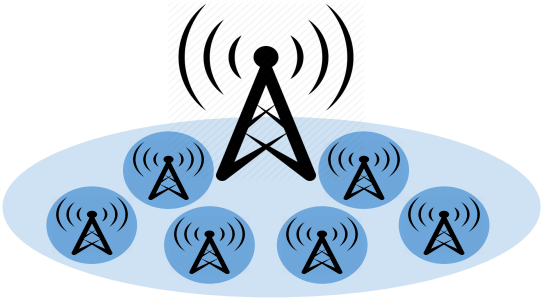




Increase of the RAN energy consumption

- Sustainability issues
- Climate change
- Growth of RAN operational cost

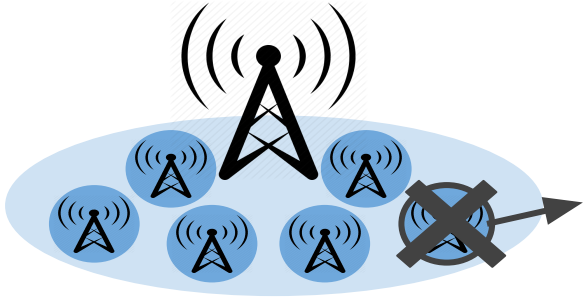
Need **RAN management** to reduce the RAN energy consumption, without QoS deterioration

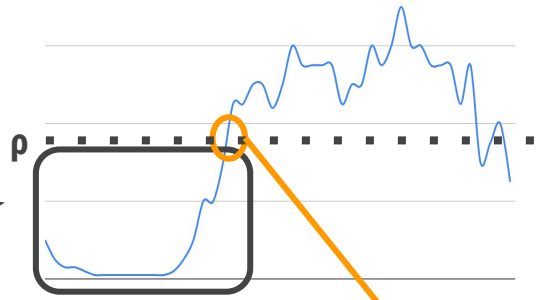


*Cisco Annual Internet Report (2018–2023)

RAN Management

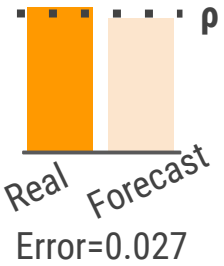
- Microcell BSs switching according to the traffic demand





ρ depends on the energy consumption per carried bit:
when the **traffic is below ρ**,
$EC_{MACRO}(T_{MACRO}+T_{\mu}) < EC_{MACRO}(T_{MACRO})+EC_{\mu}(T_{\mu}$

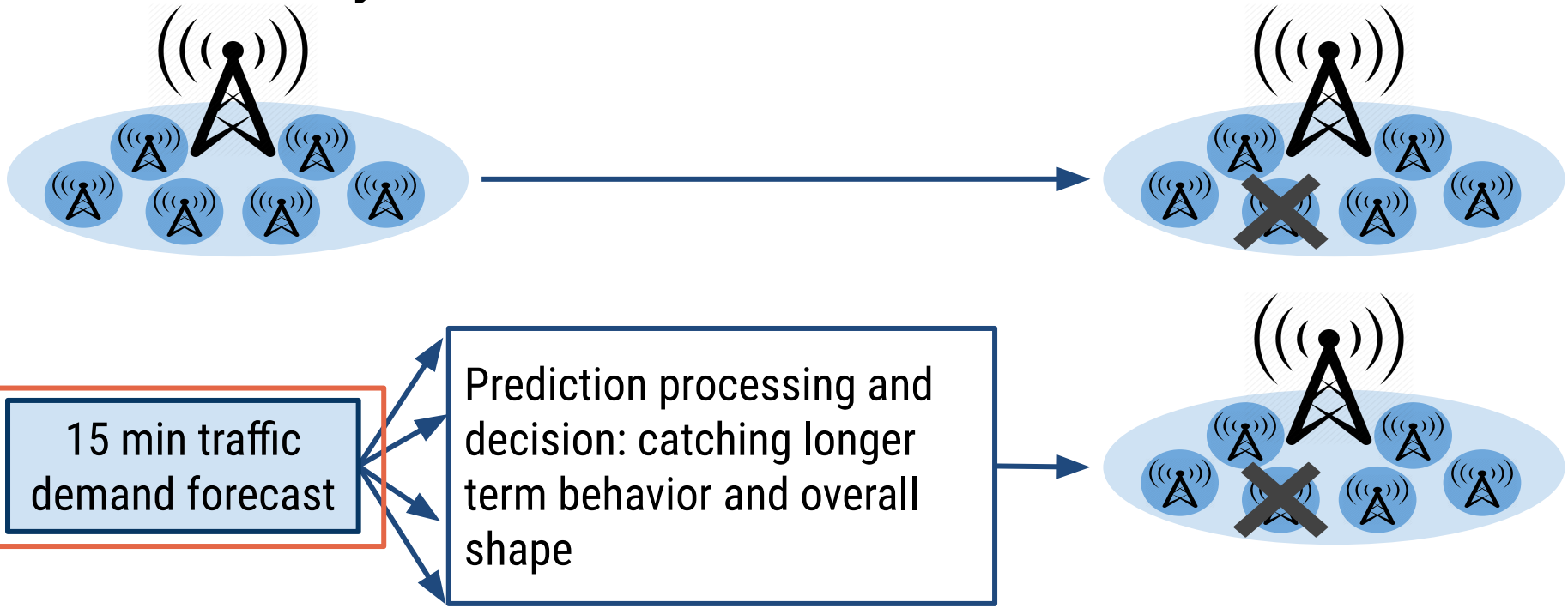
- Need to know near future traffic demand:
  Machine Learning for traffic predictions
  - QoS deterioration because of incorrect microcell BSs deactivation
  - Not only a problem of error!



Error=0.027

Need careful processing of the traffic predictions and understanding of the overall traffic pattern

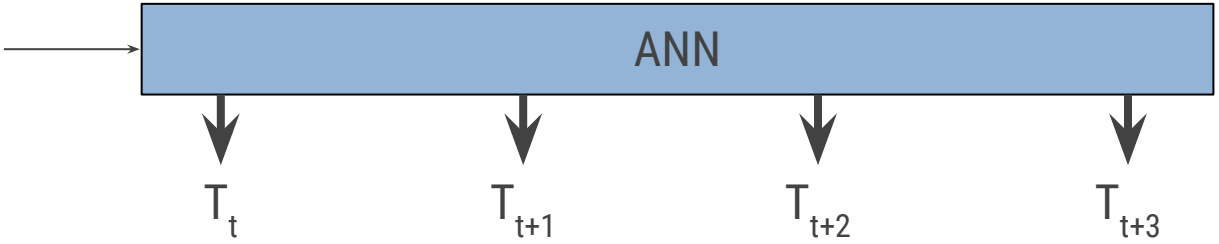
Dynamic Resource Allocation in RAN



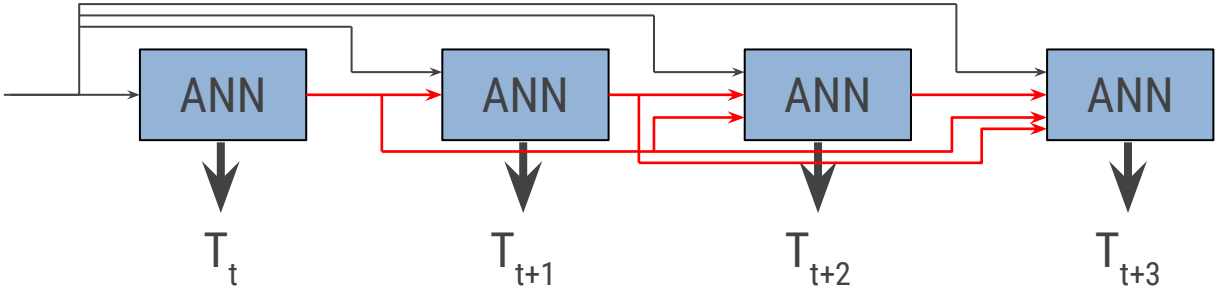
15 min traffic demand forecast

At time t, predict traffic in the next 4 time slots (15 min long):

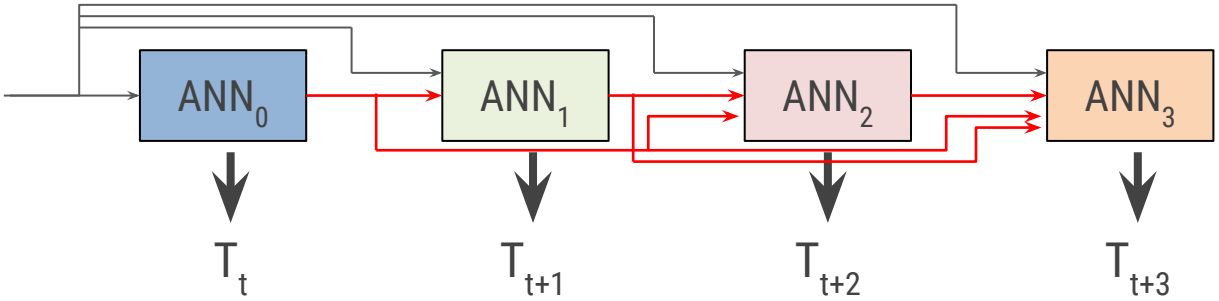
- **1 ANN - 4 outputs**



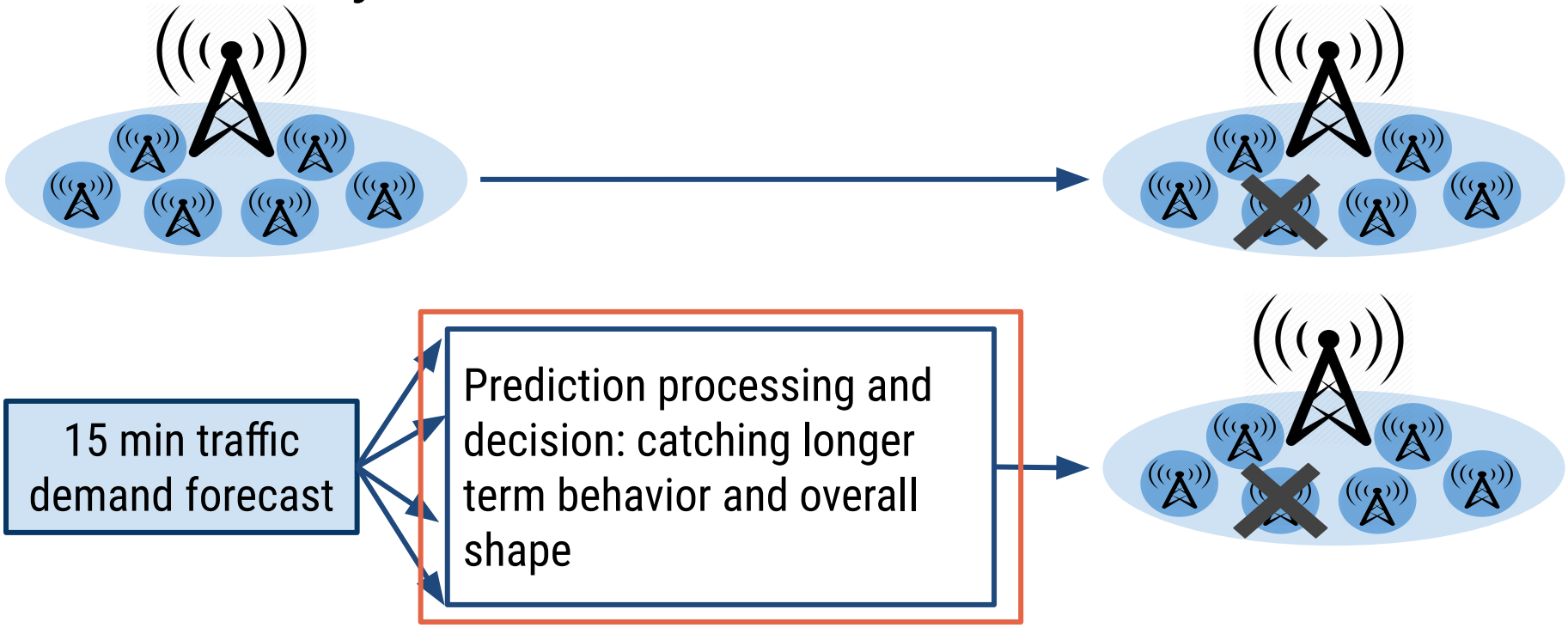
- **1 ANN - 1 output**



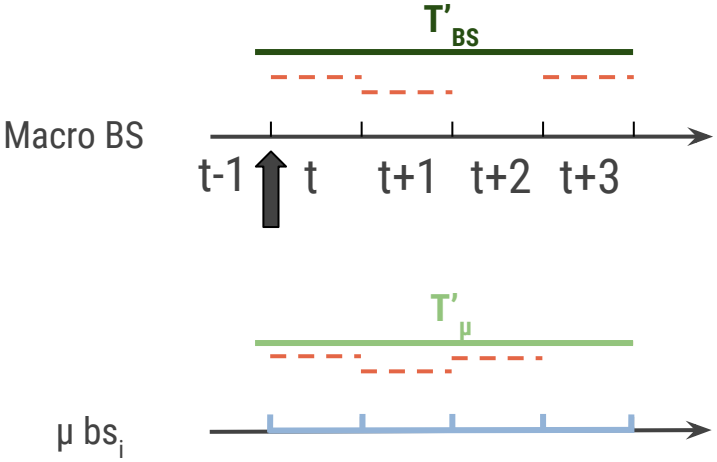
- **4 ANNs - 1 output**

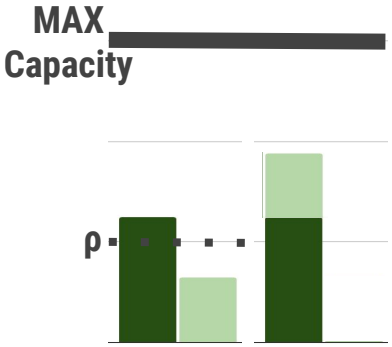


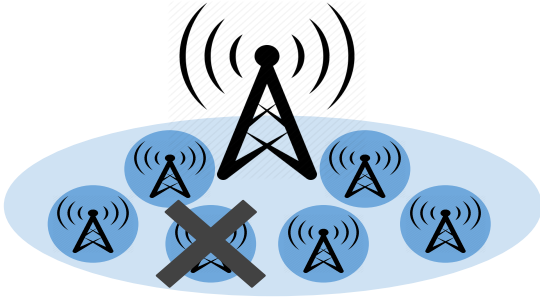
Dynamic Resource Allocation in RAN



Taking decisions: Max based

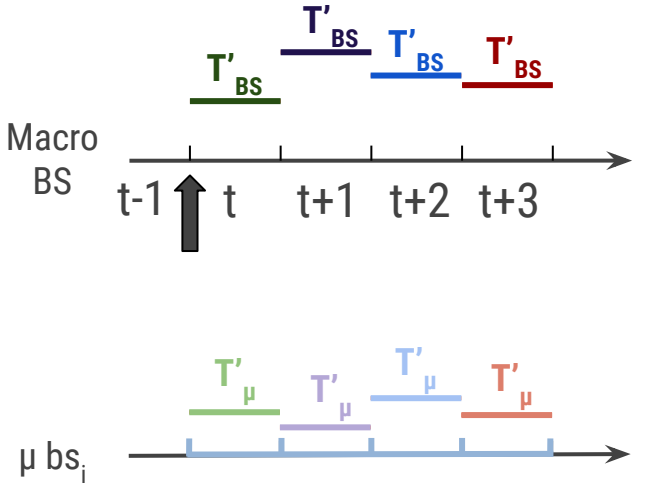


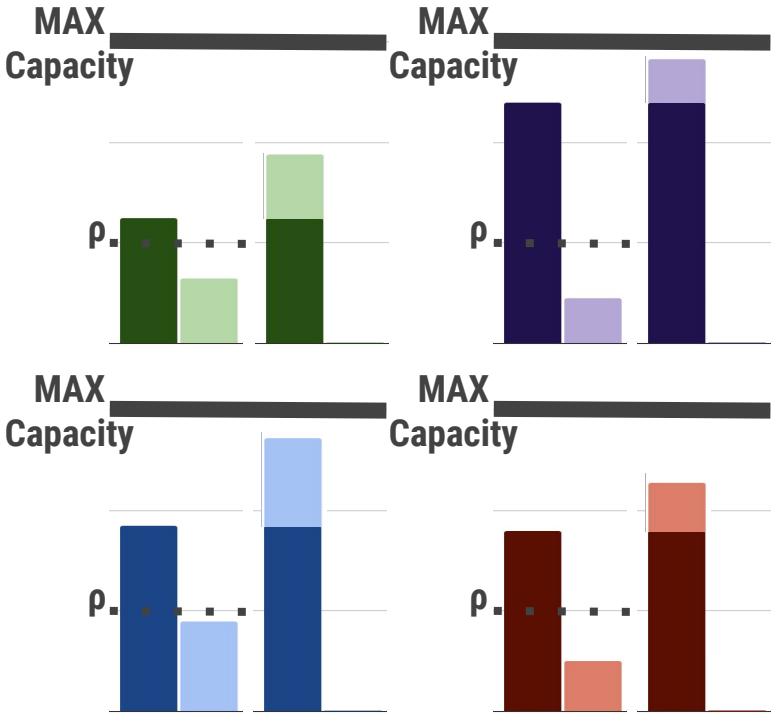


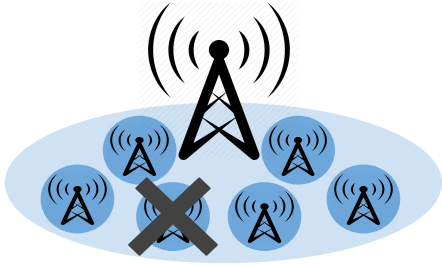


- **Max2Max**: Take decision based on max estimates; decide at the hour
- **Max2Max cont**: Take decision in any 15 min slot

Taking decisions: Interval based

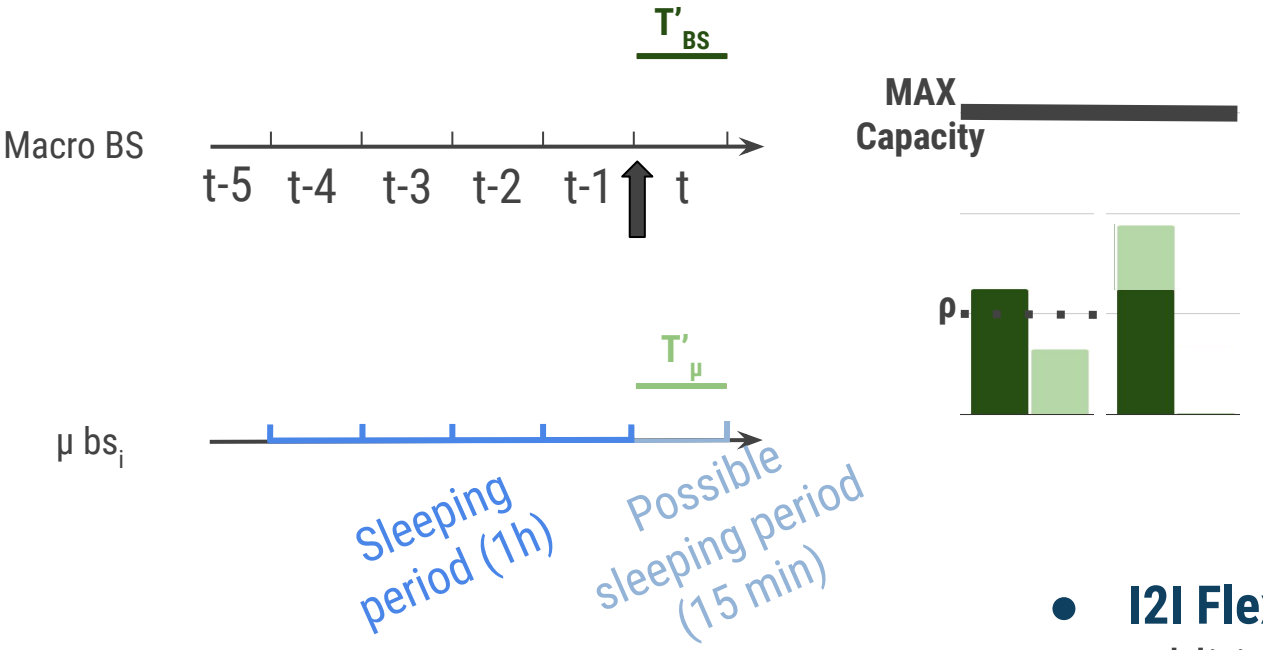






- **I2I**: Take decision based on slot by slot estimates; decides at the hour
- **I2I cont**: Take decision in any 15 min slot

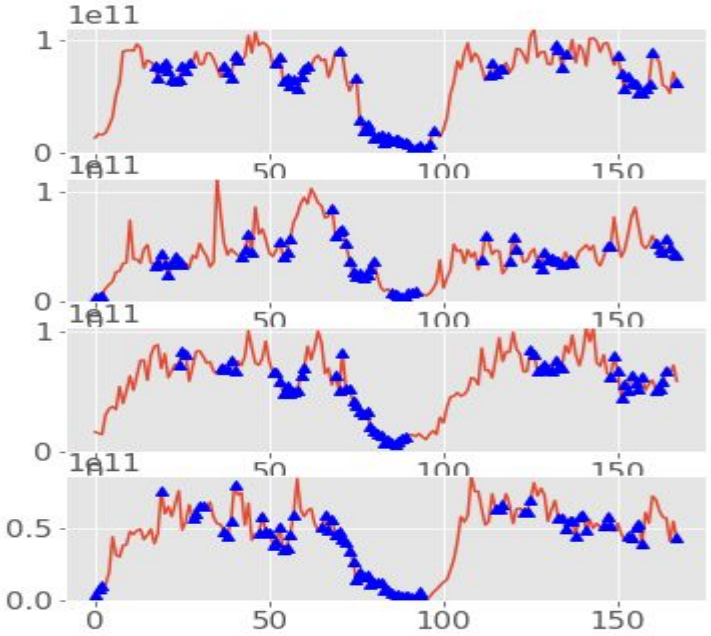
Taking decisions: Interval based

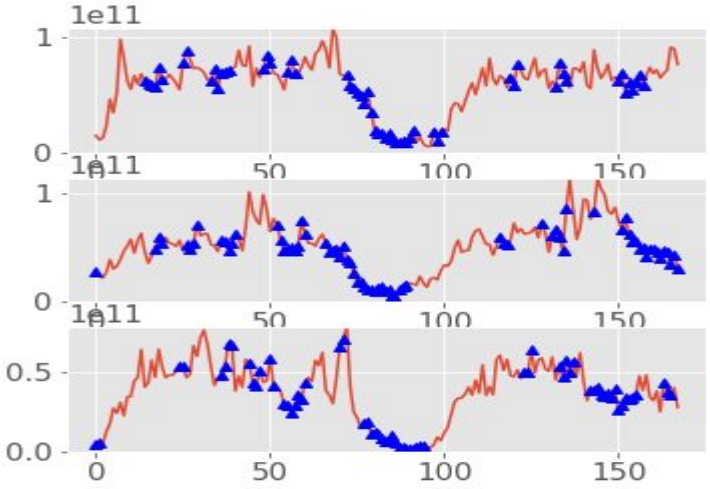


- **I2I Flex**: After a sleeping period an additional slot can be considered

Detecting descendent fronts

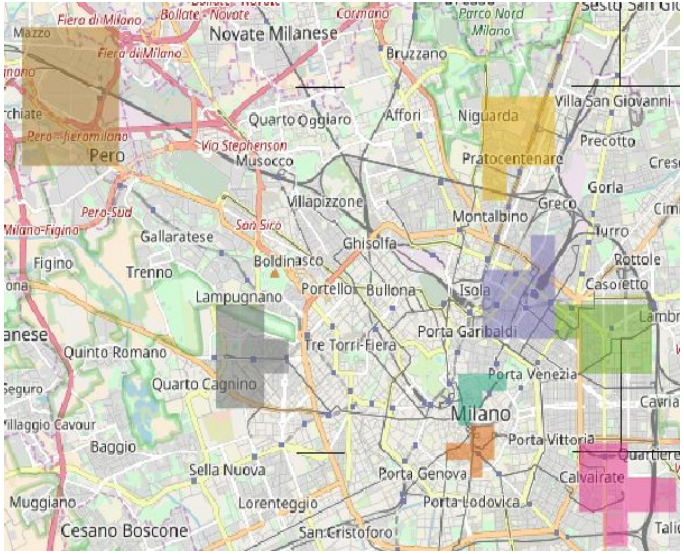
Catching longer term behavior and overall shape can help making decisions



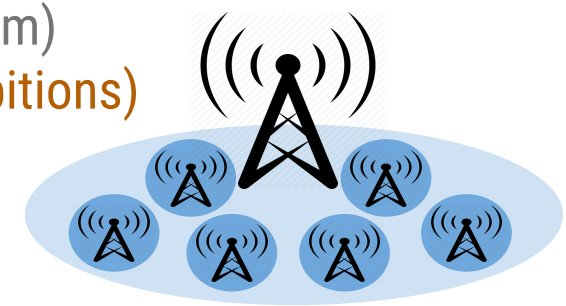


Fronts are detected with averages and sliding windows of the past 2 h samples

Scenario and Used Data

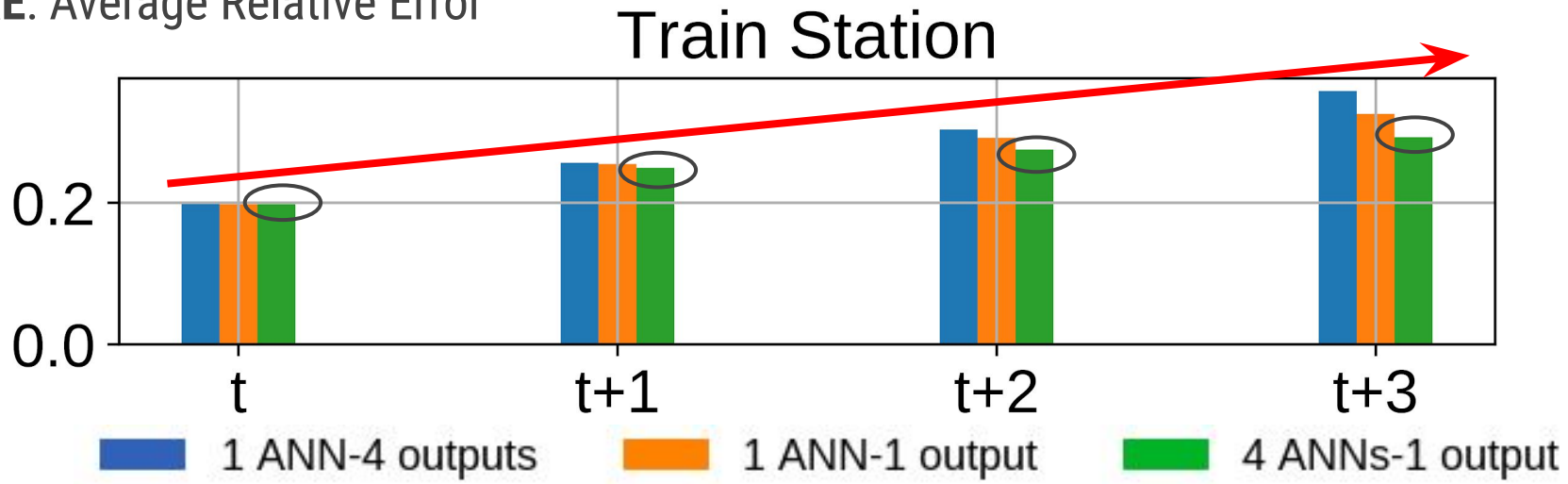


- Residential
- Business
- Politecnico di Milano (campus)
- Duomo (turistic)
- Industrial
- Train station
- San Siro (stadium)
- Rho Fiere (exhibitions)



Choice of the ANN

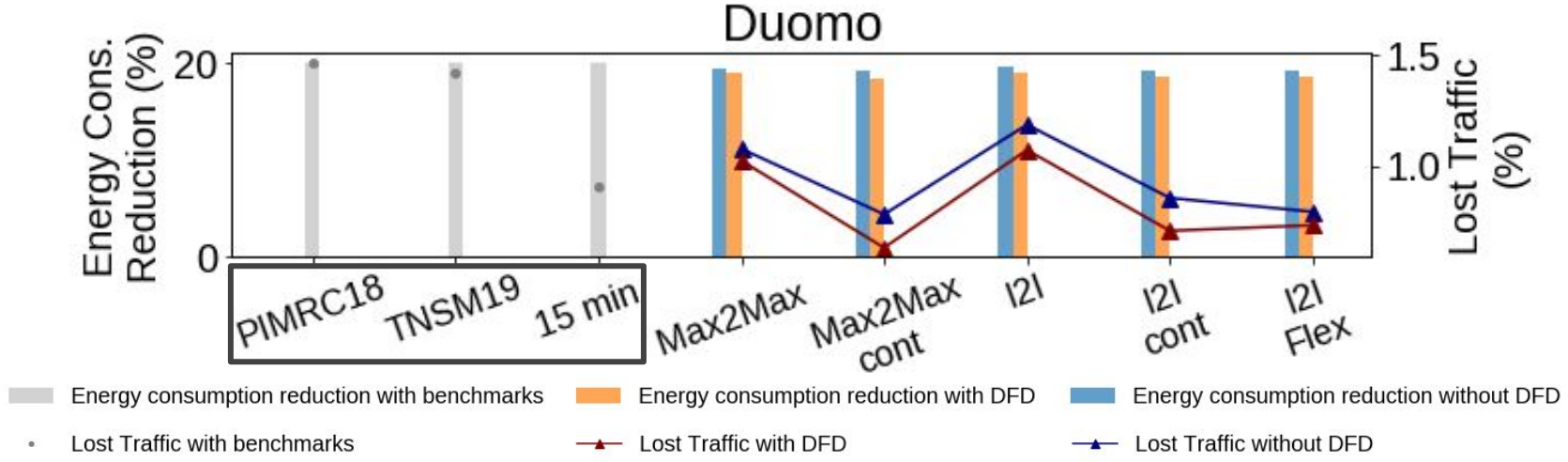
ARE: Average Relative Error



➔ clearly, error grows with time depth

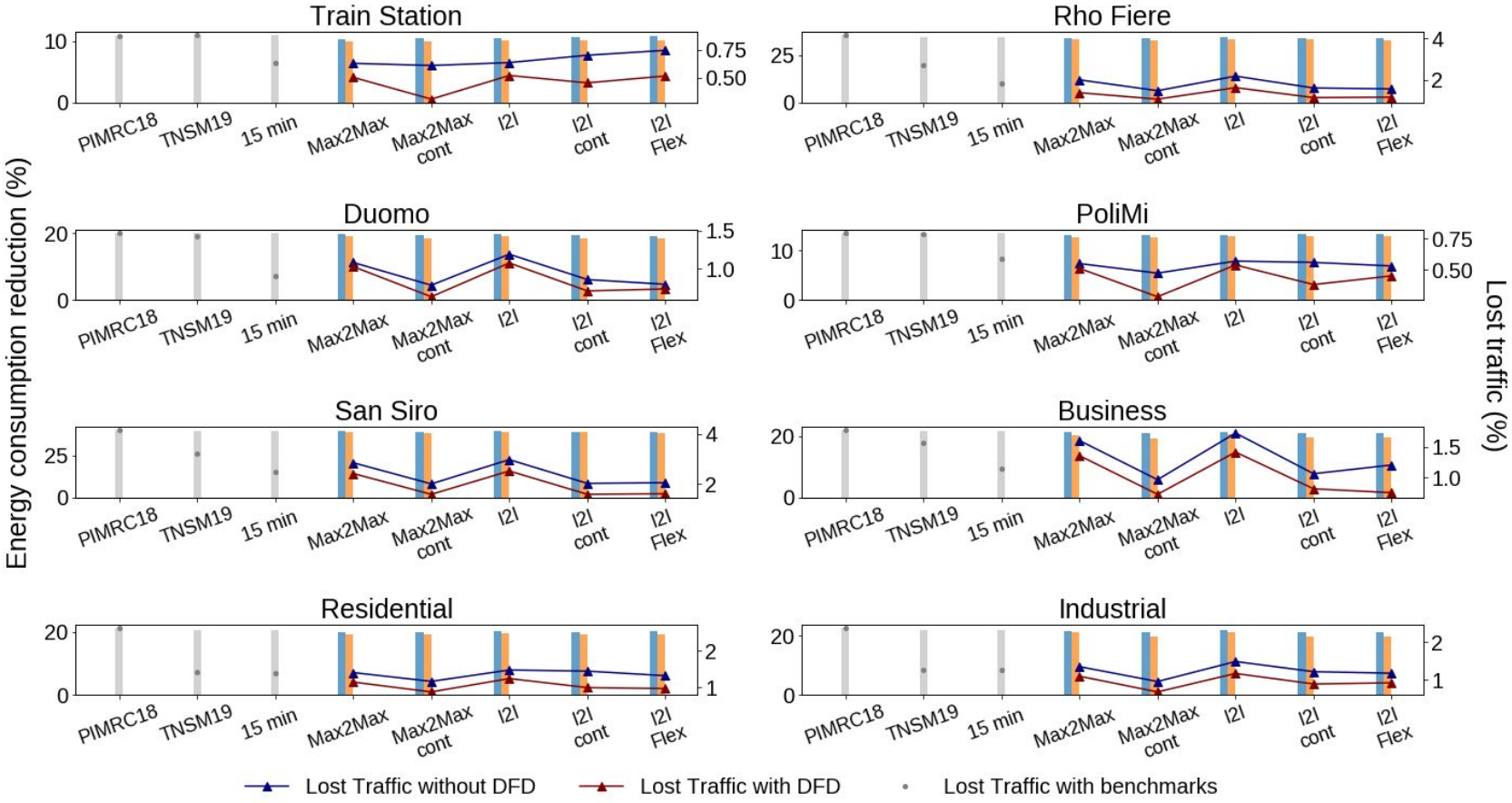
➔ 4 ANNs scheme works slightly better

Taking decision



- ➔ Energy consumption slightly increases wrt benchmarks (at most by 3%)
- ➔ Lost traffic improvement:
  - when Max based approaches w.r.t. interval based
  - when *cont.* is used
  - when *DFD* is used

Taking decision



Conclusion

- RAN sustainability is a key challenge that requires the adoption of network management strategies, which use traffic demand predictions

- ML algorithms for predicting demand for services are effective if properly processed:
  - to combine predictions over **shorter time** scales (15 min instead of 60 min traffic samples)
  - to detect the **overall shape** of traffic profile

- Future works:
  - 5G scenario: dense RAN, which uses MEC technology
  - Measure of energy consumption for ML training

Thank you for your attention