Real-World Performance of current Mesh Protocols in a small-scale Dual-Radio Multi-Link Environment

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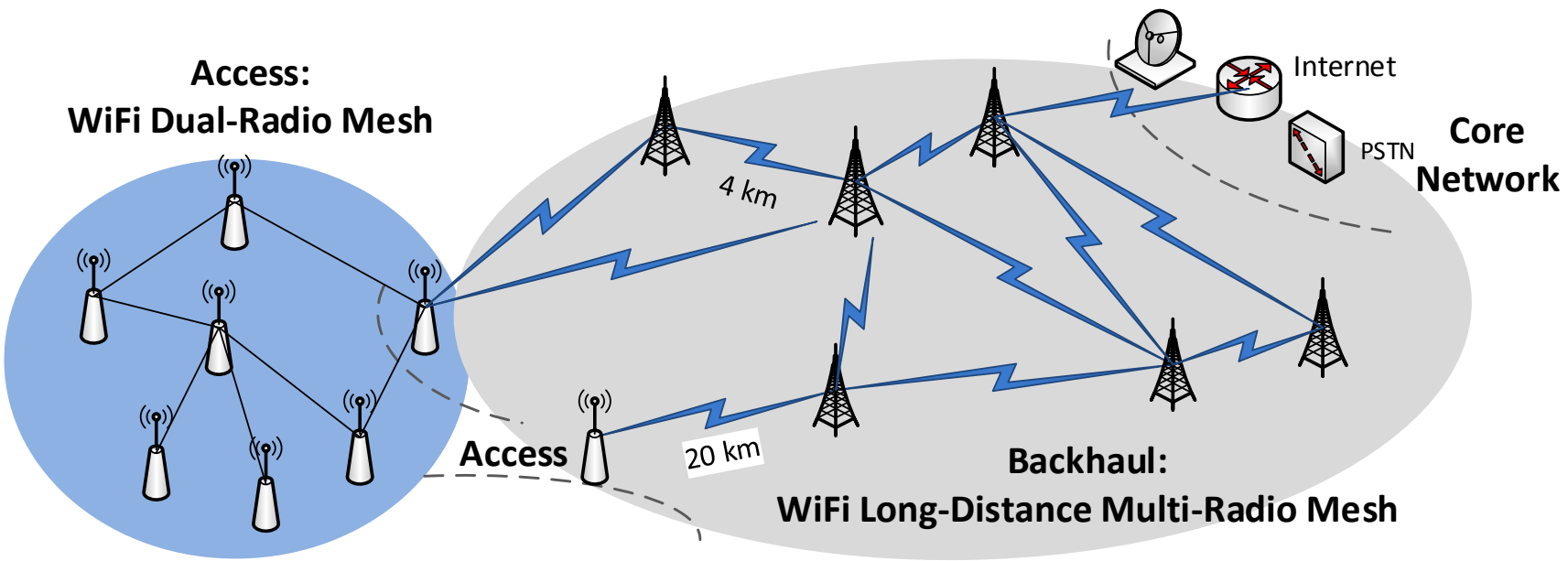
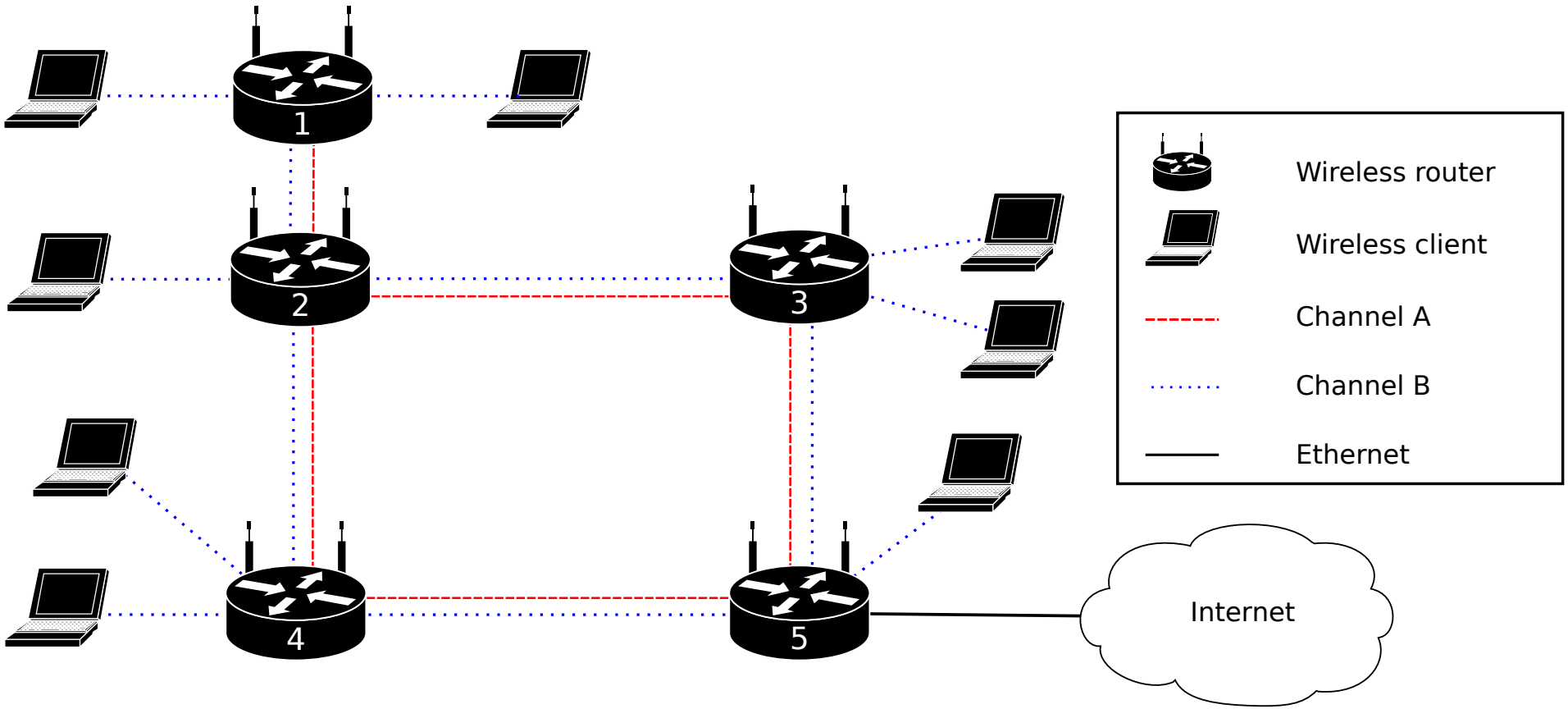
Introduction and motivation - Internet in rural areas

- ✓ Using a cost-efficent technology to bring connectivity to rural areas.
- ▸ Local distribution of connectivity is the next step.
- ▸ Dual-Radio WiFi Mesh Networks are (among others) one option:
  - Which mesh protocol to prefer?
    [Babel, B.A.T.M.A.N. V, BMX7, OLSRv2]
  - Which dual-radio setup to prefer?

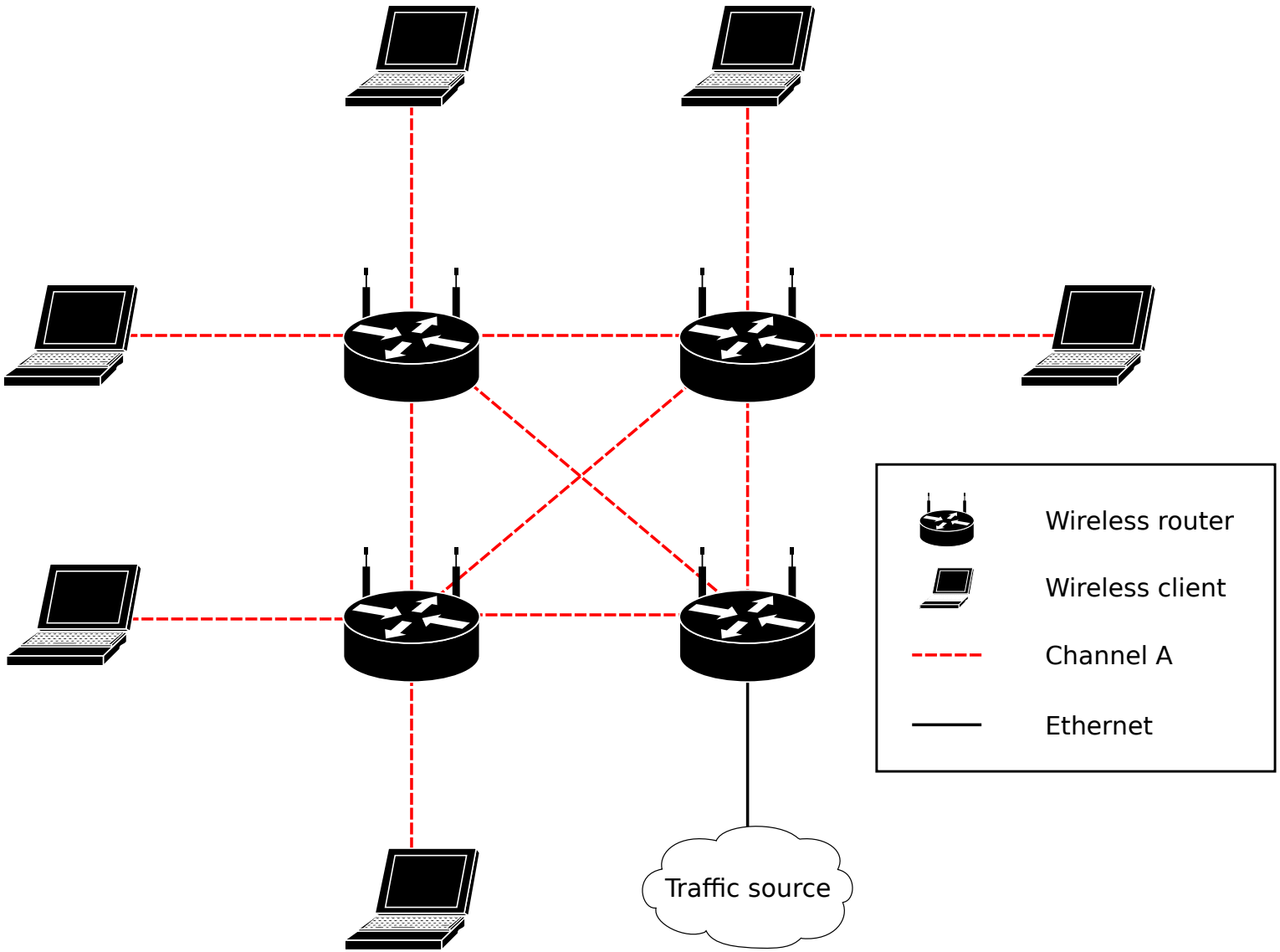


Dual-radio mesh networks



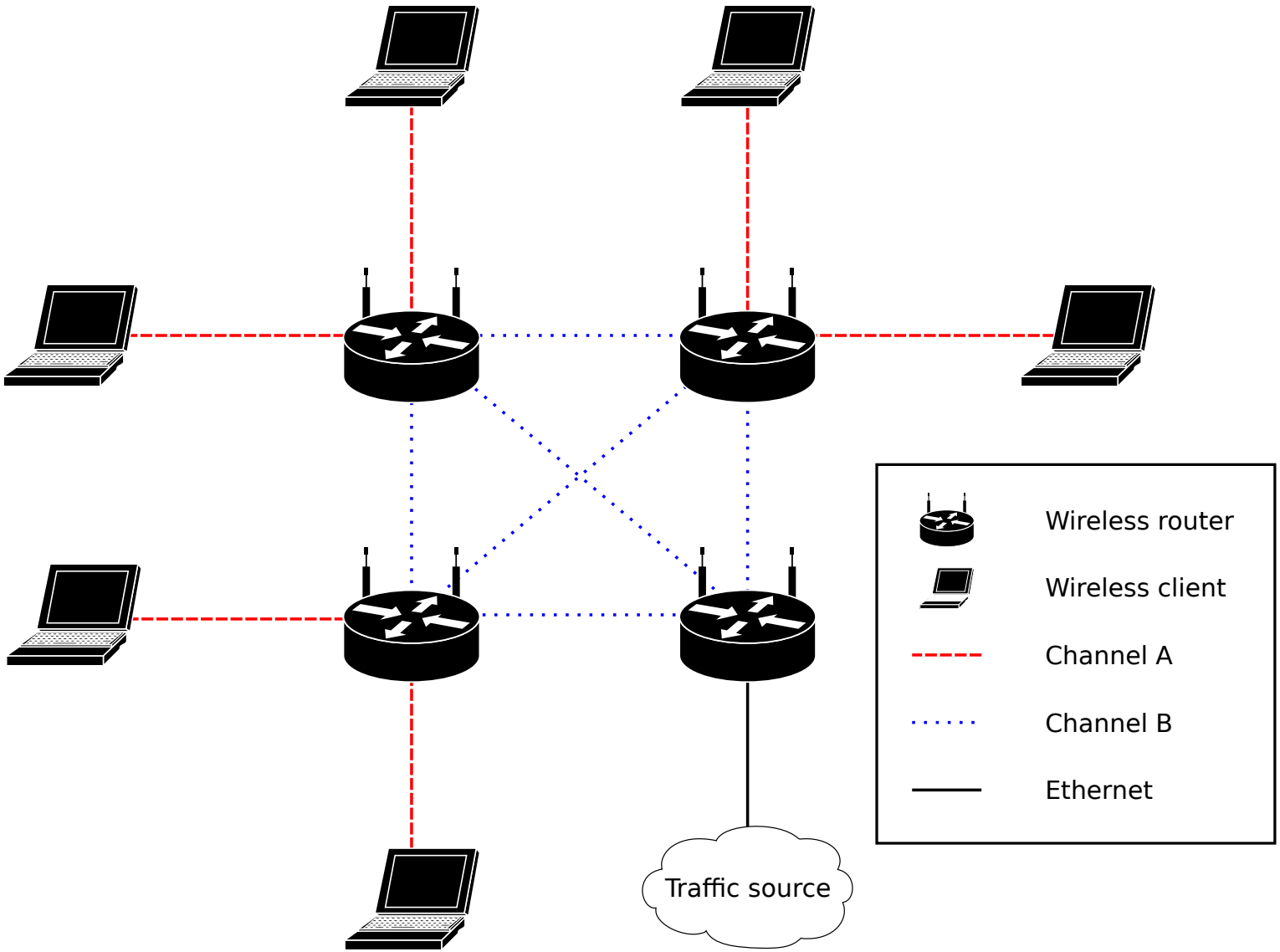
Example of a wireless mesh network with two radios attached to each router.

Setup 1



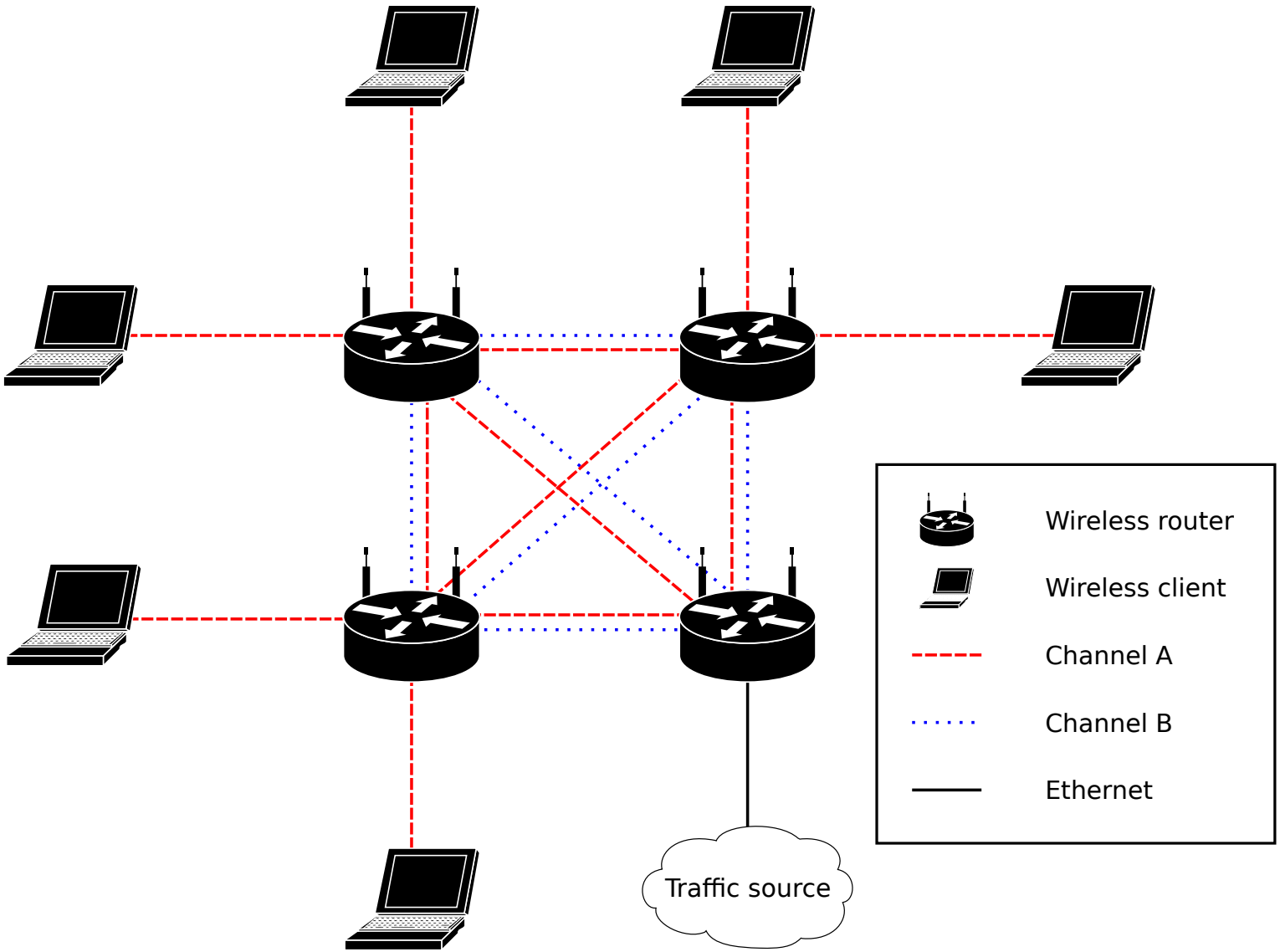
Setup 1 for the experiments: One radio for everything on one channel; second radio unused.

Setup 2



Setup 2 for the experiments: One radio for the mesh on one channel and another radio with a different channel for the clients.

Setup 3

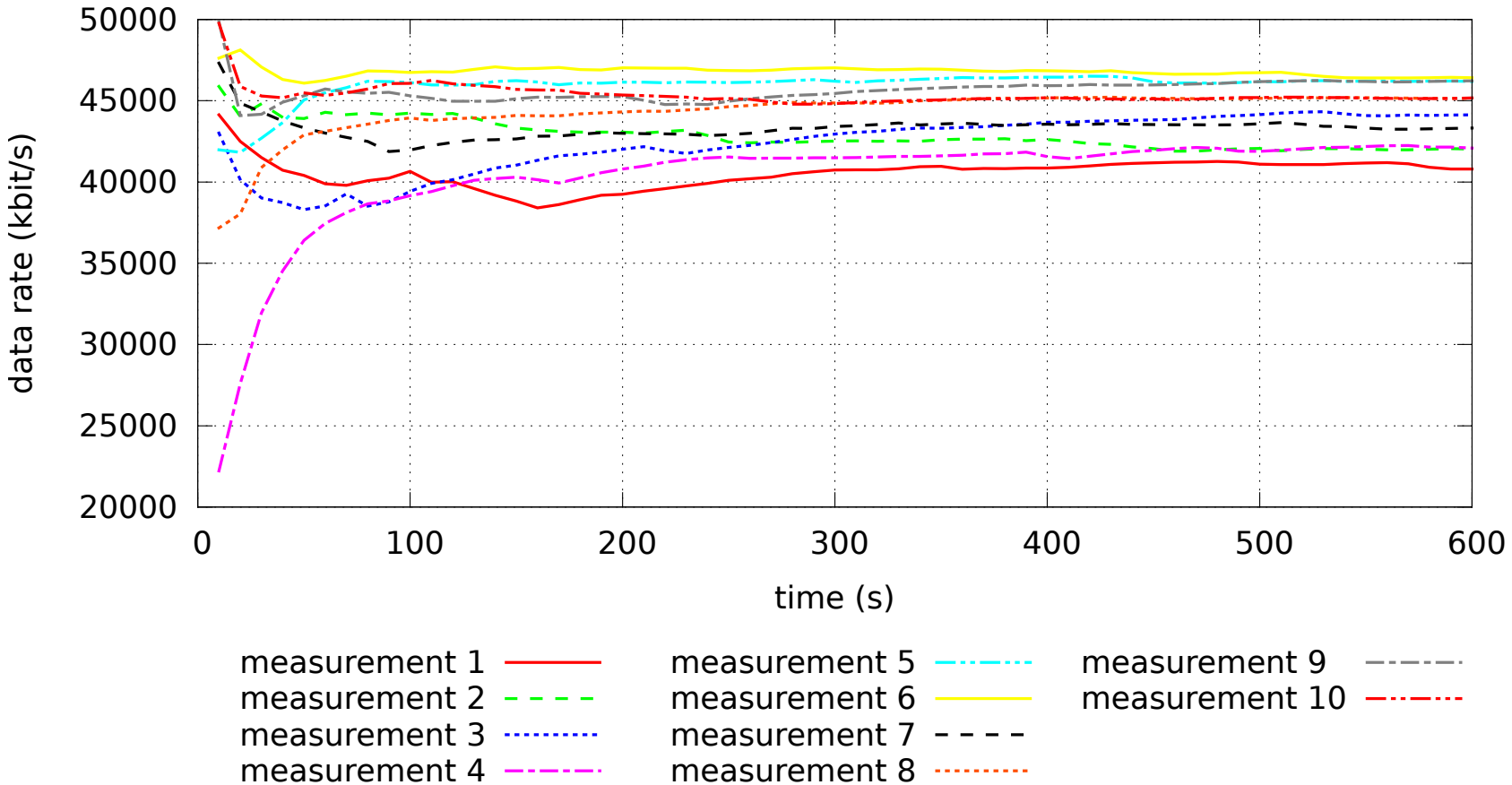


Setup 3 for the experiments: One channel for both mesh network and clients and a second radio with another channel for the mesh network.

Preliminary considerations for the experiments

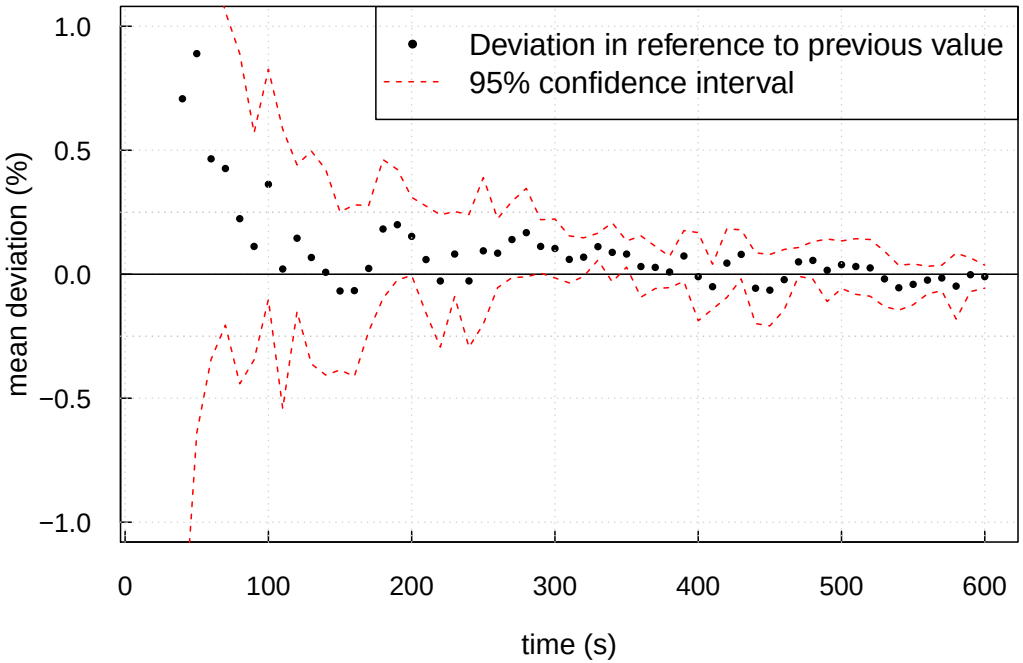
- Has the system to “warm-up”? For how long?
- How to generate traffic? And for how long?
- How to get the measurement reproducible?
- How to prevent that different measurements affect each other?

Length of measurements



Development of the data rate over a period of 10 minutes. Intermediate values were taken every 10 seconds and always the overall data rate since the start is calculated. (Babel, Setup 3)

Length of measurements



Development of the data rate over a period of 10 minutes. The mean percentage deviation in reference to previous mean value is shown. (Babel, Setup 3)

Percentage deviation:

$$rel\_dev_{x_{10}-x_{20}} = \frac{x_{20} - x_{10}}{x_{10}} * 100$$

Confidence interval:

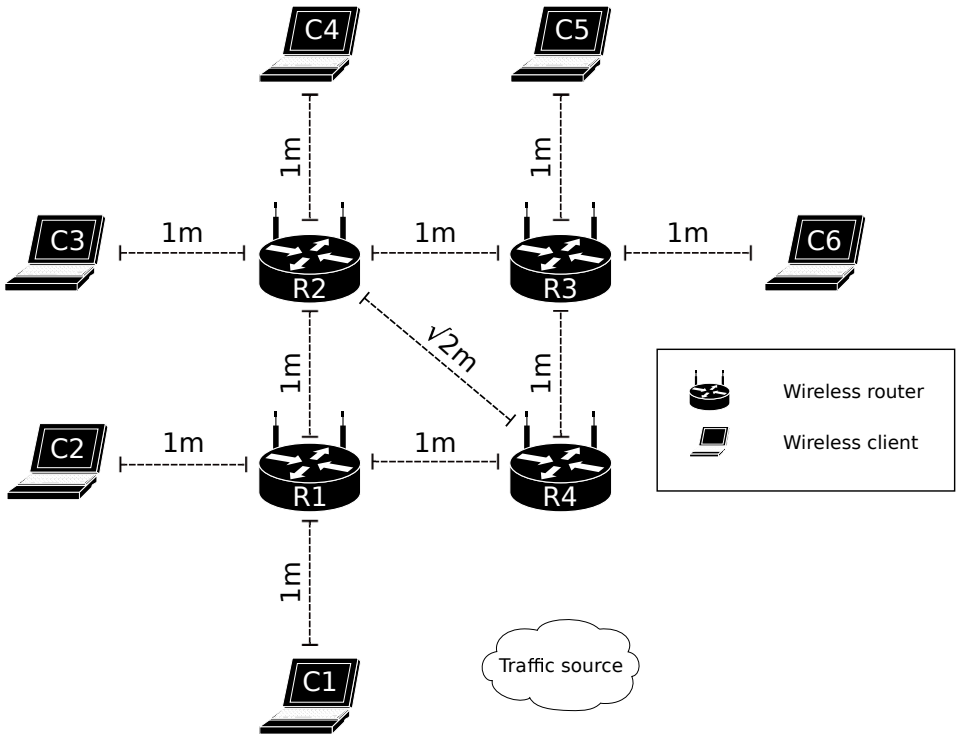
$$[\overline{x} \pm t_{n-1,1-\alpha/2} * \frac{s}{\sqrt{n}}]$$

α = confidence level

n = number of observations

$$s = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(x_i - \overline{x})^2}$$

Reproducibility / test procedure



Physical placement of nodes.

Picture of the setup (in an underground parking lot).

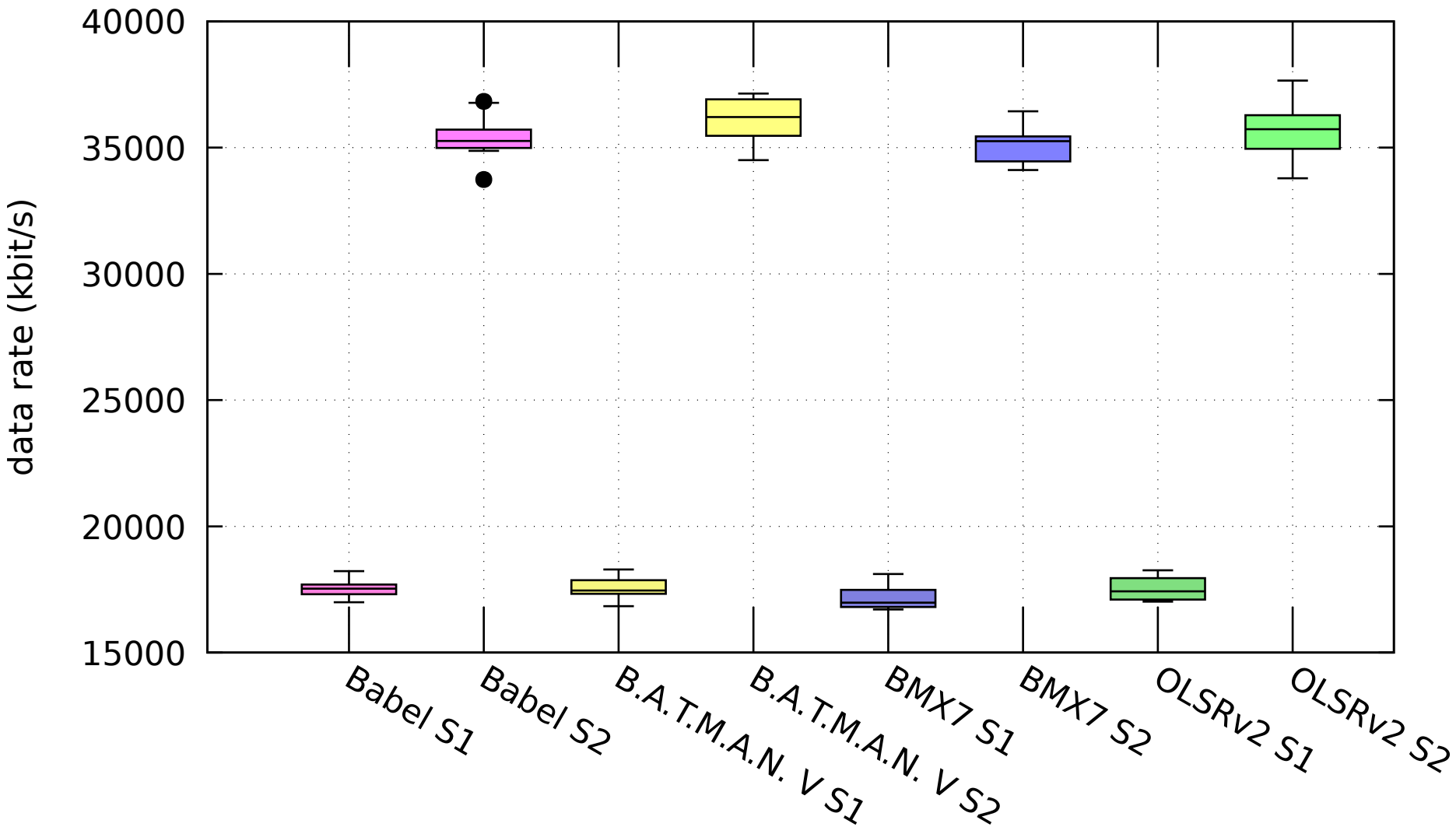
Hypothesis

1. Using dual-radio routers compared to single-radio routers doubles the achievable data rate for clients.
   - 2 channels = 2 * bandwidth = 2 * data rate

2. The mesh routing protocol influences the results, although all routers are direct neighbors.
   - Different overhead for each protocol

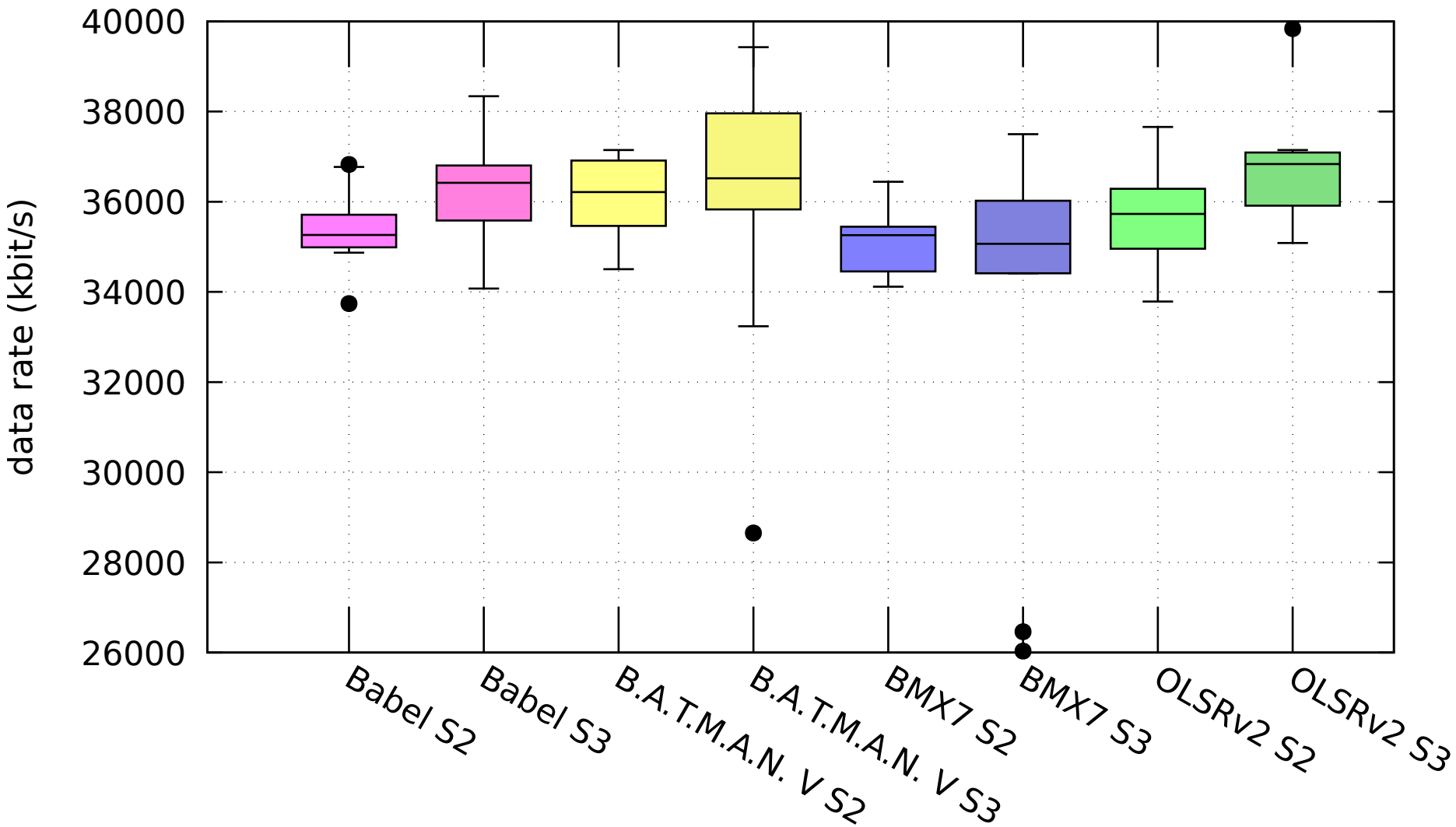
3. Using both channels for the mesh (Setup 3) is worse than having a dedicated channel for all clients and one for the mesh (Setup 2).
   - More mesh protocol overhead
   - The routing protocol may use the channel which is occupied by the clients

Results: Single channel (S1) vs dual channel (S2)



Box plot of the results of Setup 1 and 2. Each box plot consists of ten measurements, where each data point is the sum of the six client results.

Dedicated access (S2) vs mixed mesh/access (S3)



Box plot of the results of Setup 2 and 3. Each box plot consists of ten measurements, where each data point is the sum of the six client results.

Conclusion

- Mesh protocols have specific features for multi-radio networks.
- Expected: Dual-radio routers = 2 * data rate of single-radio routers.
- Not expected: Different mesh protocols lead to similar results (in our scenario).
- Not expected: Using both radios within the mesh is equally good and should be preferred (in our scenario).
  - The protocol overhead is negligible in small networks

Thank you very much!

Are there any questions?

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