Weaker Links for Synchronization

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ABSTRACT

Clocks are fundamental to sensor networks, for measurement of phenomena and for coordinated actuation. A core issue in clock synchronization algorithms is the selection of which links to use for messaging. Link-level, or neighbor synchronization, has higher precision than multihop paths, due to noise and delay that includes clock drift. Most algorithms prefer highest reliability links when flooding from a clock authority to other nodes; another direction suggested in [1] is to prefer links between nodes which have low frequency error variance (essentially the same drift characteristics over time, presumably due to temperature).

The observation here is that application needs dictate the desired precision in synchronization, often related to distance between nodes, e.g. neighbors measuring the same vibration or moving image should have tightly synchronized clocks. From an application perspective, even a low-quality communication link between neighbors in close physical proximity may be a better choice for repeated synchronization messages than a long path (worst case being $O(D)$ for D the hop-diameter of the reliable link subgraph). The same observation holds for a range of different link choices made independent of tight precision application requirements for proximal nodes. The trade-off may depend on power cost of longer-path reliable synchronization algorithms compared to power cost of more frequent synchronization attempts on a low-reliability link. Not addressed in this note is how to reconcile clock authority diffusion with tight precision requirements for proximal nodes.

To make the point concrete, consider a simple example. Two sensors p and q are located on either side of a barrier; application quality of measurement is proportional to the clock agreement of p and q. Whereas the mean synchronization error would be 10 milliseconds between nodes connected by a reliable link, the mean synchronization error between p and q would be 20 milliseconds if the weak (p,q)-link is used (due to packet loss on the weak link). Suppose a path of reliable links between p and q has 8 hops, synchronization errors have normal distribution with zero bias, with mean error magnitude $t \cdot \sigma$ per link (proportional to standard deviation); then the accumulated error over the path would be $t \cdot \sqrt{8 \cdot \sigma}$ because variances of independent normally distributed variables are additive. For our example, the observed mean error could thus be about 28 milliseconds over the path, whereas using the less reliable (p,q)-link would result in a better measurement for the application.

BODY

Weak links can be a better choice than reliable links for clock synchronization in a wireless sensor network.

REFERENCES

[1] T Schmid, Z Charbiwala, Z Anagnostopoulo, MB Srivasta, P Dutta. A case against routing-integrated time synchronization. In *Proceedings of ACM SenSys'2010*, pp.267-280, 2010.

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