Bounding the Lifetime of Wireless Sensor Networks

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Wireless networks composed of thousands of highly integrated sensor nodes hold the promise of sensing that is far superior, in terms of quality, robustness, cost and autonomous operation, to that offered by using a few, ultra high precision macro-sensors. Such sensor networks are expected to find widespread use in a variety of applications including remote climate monitoring and seismic, acoustic, medical and intelligence data-gathering. Due to their compact form factors, wireless sensor nodes are severely energy constrained. Furthermore, replacing batteries on up to thousands of nodes in possibly harsh terrain is infeasible. Hence, it is well accepted that the key challenge in unlocking the potential of such networks is maximizing their post-deployment active lifetime.

Effort aimed at increasing the lifetime of sensor networks is two pronged. First, the node and the physical link must be made as energy efficient as possible. Second, the collaborative strategy i.e. the strategy that governs how nodes cooperate to perform the sensing operation, must be energy efficient as well.

In this talk, our main objective is not to propose a new collaborative strategy that leads to greater network lifetime. Rather, it is to bound the network lifetime that *any* collaborative protocol can ever hope to achieve. In the first part of the talk we compute such bounds for basic data gathering scenarios using simple, non-constructive techniques. While this approach results in easy-to-use, closed form expressions for lifetime bounds, it does not factor in network topology and does not accommodate aggregation of data streams. In the second half, we propose a new approach which, in principle, permits derivation of bounds for networks with arbitrarily complex capabilities, although the computational costs of such derivations may be prohibitive. We then show that for several practically useful scenarios, including sensor networks with a specified topology that allow aggregation, this approach in fact leads to polynomial time bound derivation.