## Aging Analysis in Large-scale Wireless Sensor Networks

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Prior research on the lifetime of wireless sensor networks has focused primarily on the energy depletion of the very first node. In this study, we analyze the entire **aging process** of the sensor network in a periodic data gathering application. First, we examine the impact of node death on connectivity to the sink with respect to hop level in a multi-hop data gathering tree. It is observed that the cascading effect of node death on the connectivity from the first-hop to longer hop levels with the existence of multiple alternate paths leads to a power law relation, where the probability of connection to a sink decreases in proportion to the hop level with an exponent, when device failure occurs over time. Then, we provide distance-level analysis for the dense deployment case by taking into account the re-construction of a data gathering tree and workload shift caused by the energy depletion of nodes with larger workload. Extensive simulation results obtained with a realistic wireless link model as well as real connectivity information using empirical data are compared to our analytical results. Finally, we show through an analysis of the aging of first-hop nodes that increasing node density with a fixed radio range does not affect the network disconnection time. Our analysis explains a wide range of aging behaviors under different network operation and deployment conditions, and provides useful insights for planning, deploying and maintaining long-lived networks.