

Emergent Dynamics of Information Propagation in Large Networks

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Summary

Large scale networked systems that include heterogeneous entities, e.g., humans and computational entities are becoming increasingly prevalent. Prominent applications include the Internet, large scale disaster relief and network centric warfare. In such systems, large heterogeneous coordinating entities exchange uncertain information to obtain situation awareness. Uncertain and possibly conflicting sensor data is shared across a peer-to-peer network. Not every team member will have direct access to sensors and team members will be influenced mostly by their neighbors in the network with whom they communicate directly. In this talk I will present our work on the dynamics and emergent behaviors of a large team sharing beliefs to reach conclusions about the world. Unlike past work, the nodes in the networks we study are autonomous and actively fuse information they receive. Nodes can change their beliefs as they receive additional information over time.

We find empirically that the dynamics of information propagation in such belief sharing systems are characterized by information avalanches of belief changes caused by a single additional sensor reading. The distribution of the size of these avalanches dictates the speed and accuracy with which the team reaches conclusions. A key property of the system is that it exhibits qualitatively different dynamics and system performance over different ranges of system parameters. In one particular range, the system exhibits behavior known as scale-invariant dynamics which we empirically find to correspond to dramatically more accurate conclusions being reached by team members. Due to the fact that the ranges are very sensitive to configuration details, the parameter ranges over which specific system dynamics occur are extremely difficult to predict precisely. I will present results on the emergent belief propagation dynamics in those systems, mathematical characterization of the systems' behavior and distributed algorithms for adapting the network behaviors to steer the whole system to areas of optimized performance.