Performance Diagnosis of Services in Dynamic Networks

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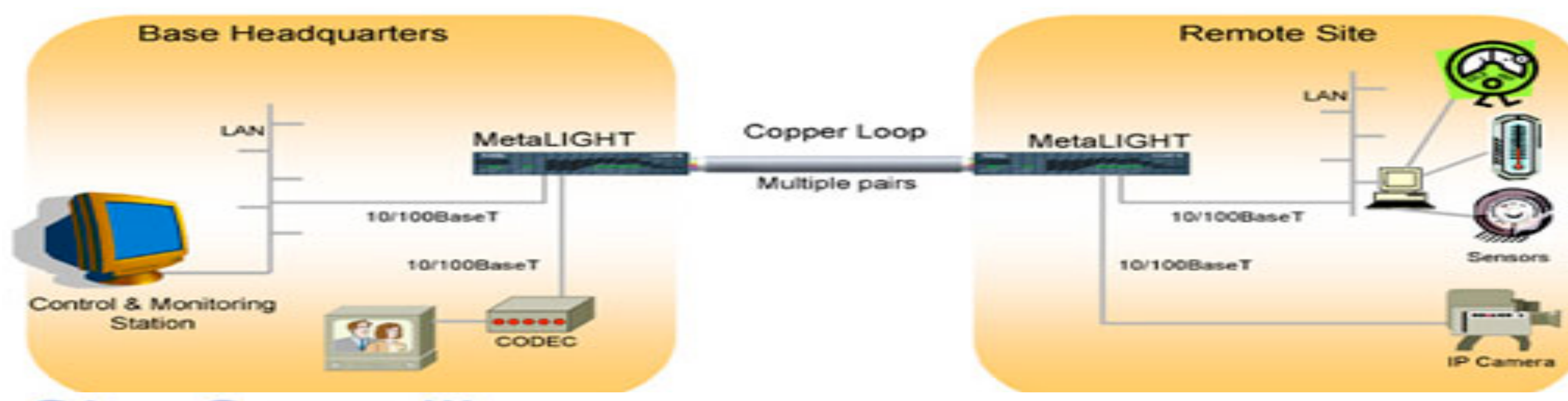
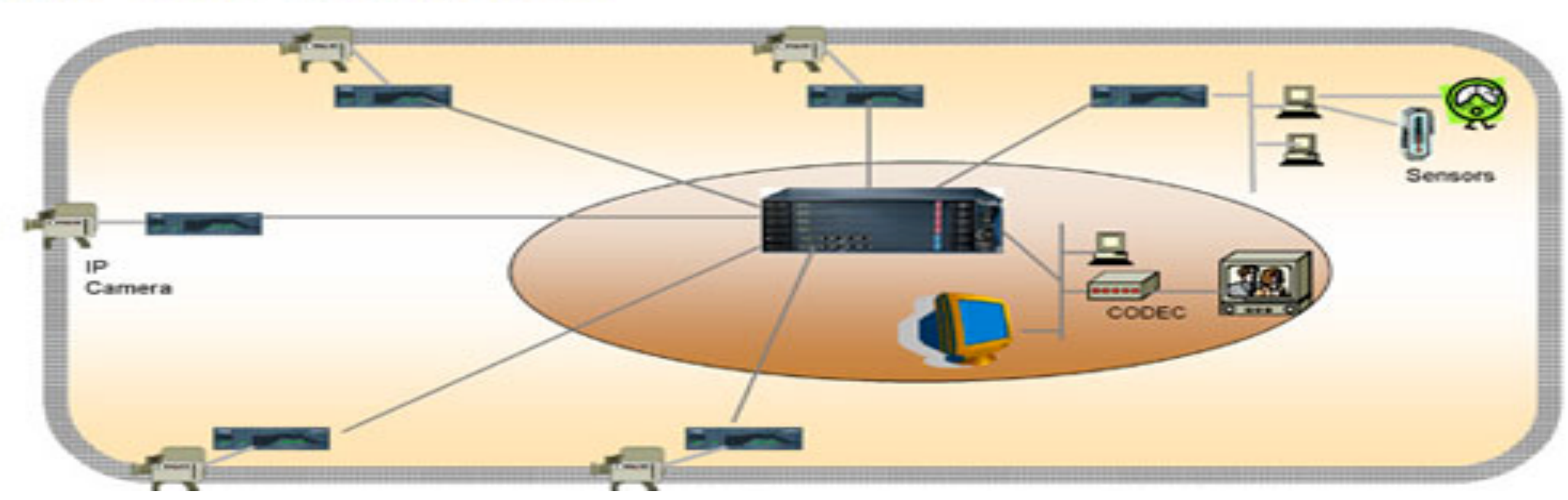
- Given a MANET where services are hosted by mobile nodes
- Degradation in performance is observed while accessing services
- Goal is to determine the states of individual services (**Problem Diagnosis**) to diagnose the failures or bottle-necks
- Our approach is based on **Network Tomography**
  - **Inputs**: Service layer dependency graph (SLDG) and measurements of e2e client – service transactions
  - **Output**: States or availability of services
- **Challenges** addressed by our service-layer approach
  - **Dynamics:** MANETs, hybrid wireless networks etc. experience frequent changes in topology at network layer
  - **Scalability:** Bayesian approach [2] is not scalable, i.e., networks with high number of nodes and services

Remote Video Monitoring



Site Surveillance



Network Tomography

- Network tomography has been used in fault diagnosis at the network-layer level [1]
- Infers the link-level properties from the network topology and e2e measurements
- Solve a large linear system, $Y = AX$
  - Y is e2e measurements matrix, A is routing matrix and X represents internal states of the network
- **Fundamentally Underconstrained Systems**; Many solutions i.e., more false positives and less accuracy

Our Approach

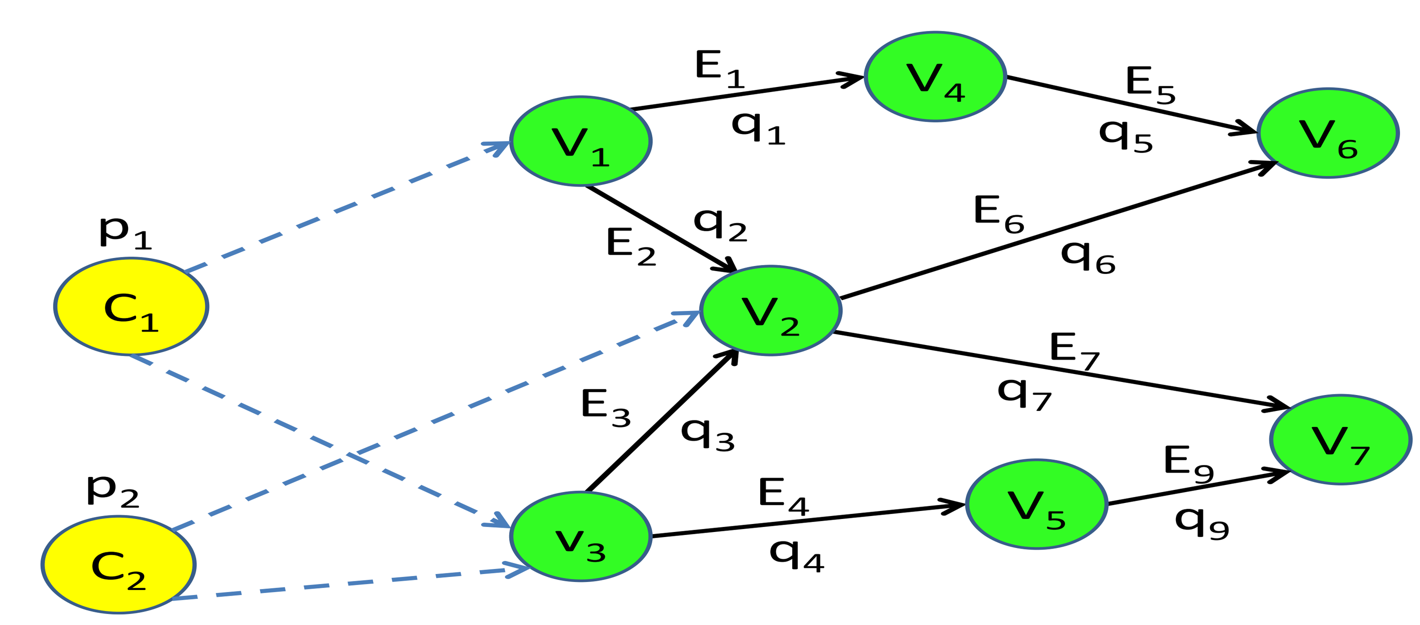


Figure 1: An Example of a global SLDG

System and Monitoring Model

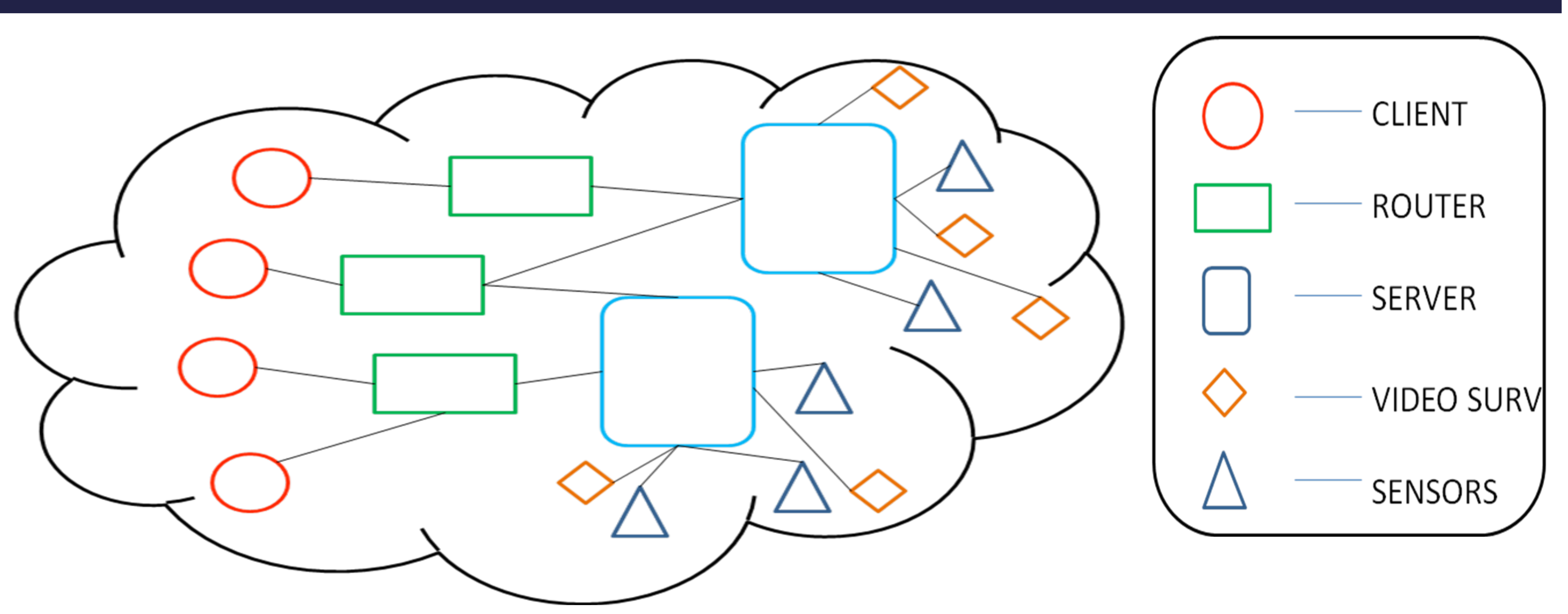
- Consider a set of clients, **C={c_1, c_2…}** that are monitored when accessing a service in the set **V={v_1, v_2…}**
- Two system-level graphs:
  - A directed acyclic graph (DAG) that represents the local dependency graph for a single client
  - Composition of services (subset of services) for each client-service transaction acquired from DAG
  - The global SLDG (Fig. 1) is the union of all local dependency graphs
- Gather measurements to evaluate,
  - q_j (Fig. 1) is success probability of inter-service transaction
  - p_i (Fig. 1) is success probability of client-service transaction
  - $p_i = 1 - \prod_{j \in E_i} (1 - q_j)$

Tomography Based Algorithm

$$Y = AX$$

- $Y = (y_1, \cdots, y_{|C|}),\ y_i = \ln(1 - p_i)$
- $X = (x_1, \cdots, x_{|E|}),\ x_j = \ln(1 - q_j)$
- A is dependency matrix
- Ranking all possible causes
  - **Spatial correlation** of nodes that offer services
  - **Policies** that are employed across networks

Evaluation



- ns3 simulator
- 50 mobile nodes
- 30 services (5 front-end + 25 back-end) placed randomly on mobile nodes
- Each service has multiple functionalities
- Taken measurements (probability of success) for different time windows
- Evaluate accuracy of diagnosis for different cases

References

[1] R. Castro, M. Coates, G. Liang, R. Nowak, and B. Yu, "Network tomography: recent developments," Statistical Science, vol. 19, pp. 499– 517, 2004.

[2] R. Zhang, S. Moyle, S. McKeever, and A. Bivens, "Performance problem localization in self-healing, service-oriented systems using bayesian networks," in Proceedings of the 2007 ACM. SAC '07.

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