**Bio-Inspired Disaster Response Networks**

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**Background**
- Large-scale natural disasters (e.g., Earthquake, Hurricane) –
  - Three times as many disasters between 1980 and 2016 compared to 1940-1980. (EM-DAT – The International Disaster Database)
- Since 1990, 217 million people affected each year. (The New England Journal of Medicine)

- Aftermath a disaster,
  - Loss of human lives and property
  - Lack of food, clean drinking water, shelter etc.
  - Disruption of infrastructure networks (e.g. cellular towers) and other public infrastructures (e.g. power sources) – Our focus!

- After Nepal Earthquake 2015,
  - Communication breakdown: Approx. 800 out of 2600 cellular sites were down across Nepal. 300 out of 500 KTM (worst affected district)
  - Power outage: 12 out of 15 hydropower facilities were non-functional

**Motivation**
- Construct a temporary network, termed Disaster Response Network (DRN) using smart devices, movable base stations and easily deployable antennas- for timely information exchange between survivors and responders

- State-of-the-art literature addressed high packet delivery and energy efficiency through intelligent routing protocols.
- However, no work addresses the network robustness, which is a primary requirement for DRN.

- Robustness is extremely crucial, given that DRNs are subject to -
  - intermittent connectivity (due to irregular survivor mobility),
  - defunct smart devices (due to battery depletion), and
  - component failures (due to environmental adversities)

- Network Robustness: the ability of the network to ensure steady information flow between survivors and the intended coordination center, despite component failures.

- Proposed Approach: Propose a robust and energy-efficient DRN, termed Bio-DRN that mimics the inherent robustness of a biological network of living organisms, called gene regulatory networks (GRNs)

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**Gene Regulatory Network (GRN)**
- A network of interaction between DNA segments, called genes, that regulate protein synthesis within living cells.

**Problem Formulation**
- Problem Statement: Given a GRN $G(V_e, E_e)$ and DRN $G(V_d, E_d)$, we want to determine a subgraph, bio-DRN $G_b(V_e^b, E_d^b)$ such that $|V_e^b| = |V_e|$ and $E_d^b = \max(E_d \cap E_b)$
- Formulate an ILP optimization problem

**Performance Evaluations**
- Disaster area: 10 x 10 sq. km
- Number of nodes: 250
- Pols (18-20%) and CC (2-3%) - randomly placed, Survivors are located in the vicinity of Pols
- Comparison with (i) input original DRN, (ii) Random-DRN: sparse DRN (constructed by random edge selection from original DRN), and (iii) DT-DRN: DRN with directed tree topology

**Conclusion**
- Proposed an energy-efficient yet robust DRN topology, termed bio-DRN, inspired from a biological network of living organisms.
- Formulated an ILP optimization problem and showed that it is NP-complete by reducing it to K-CLIQUE problem.
- Proposed a novel two-step mapping algorithm for the construction of bio-DRN topology.
- Performance evaluations showed that the bio-DRN achieves both energy efficiency and robustness against component failures.