Communication networks must be designed for resilience to withstand disasters and maintain critical and continuous connectivity

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Resilience-aware design of communication networks for disasters

Increasing disaster frequency exposes vulnerabilities in communication networks, where infrastructure damage and traffic surges disrupt connectivity when it is most critical. Existing approaches focus on post-disaster recovery, with limited attention to planning-stage resilience. This work motivates resilience-aware design to maintain service under disruptions through proactive strategies.

Why network resilience matters

Disasters increasingly expose vulnerabilities in communication networks, where infrastructure damage and demand surges disrupt connectivity when it is most critical. During the 2019–20 Australian bushfires, thousands of telecommunications facilities were impacted, disrupting network coverage across affected regions. Similarly, following a major earthquake in Türkiye, mobile networks experienced extreme traffic surges within minutes, placing significant strain on existing infrastructure. This highlight both the vulnerability of communication networks and the critical need for resilience.

Public protection and disaster relief

Public protection and disaster relief (PPDR) frameworks focus on restoring connectivity during disasters through reactive solutions such as temporary infrastructure and emergency deployments. As shown in Figure 1, these approaches primarily address response and recovery stages. This highlights the need for proactive, resilience-aware network design at the planning stage.

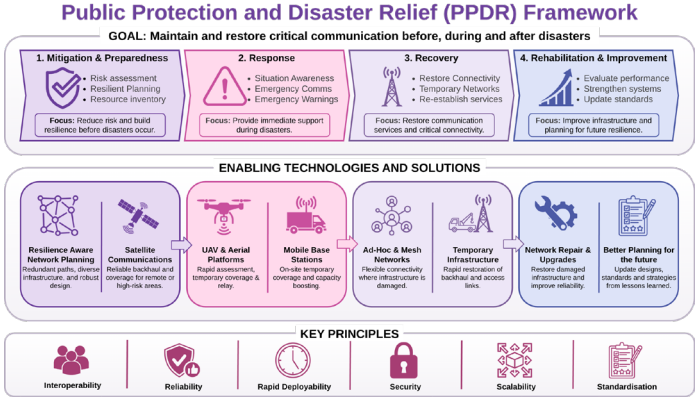

Fig. 1: Diagram of the PPDR framework.

Embedding resilience in network design

Embedding resilience at the planning stage enables communication networks to maintain service under disruptions rather than relying on post-failure recovery. As illustrated in Figure 2, traditional designs often depend on single connections and paths, making them vulnerable to failures. In contrast, resilience-aware design incorporates redundancy through multi-connectivity and disjoint paths, ensuring service continuity even when components fail.

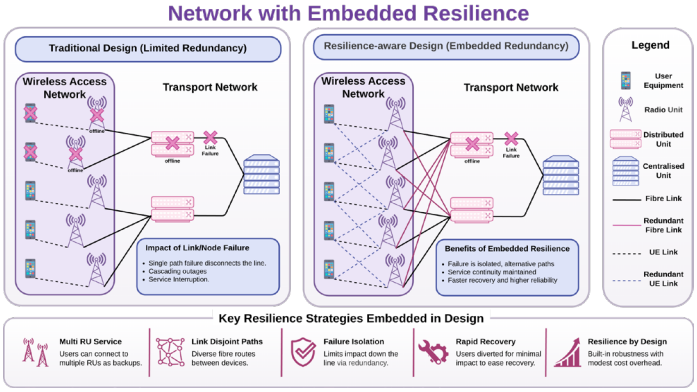

Fig. 2: Network design with and without resilience.

Research questions

To enable resilience-aware communication network design, this work proposes the following research questions:

1. How can resilience be incorporated into network planning without significantly increasing complexity or cost?
2. How can redundancy be optimally embedded within network architectures while balancing resource constraints, scalability issues, and performance requirements?
3. To what extent can planning-stage resilience reduce reliance on reactive recovery, and what are the associated trade-offs?

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