1. Ad hoc networks, particularly mobile ad hoc networks (MANETs), encounter unique challenges primarily due to their infrastructure-less nature, dynamic topology, and the need for efficient routing and connectivity maintenance. Solutions proposed in the literature address these challenges through innovative routing protocols, security mechanisms, and energy conservation strategies.

Dynamic topology management is tackled through adaptive routing protocols that can respond to changes in network configuration in real-time. For routing, protocols like AODV (Ad hoc On-Demand Distance Vector) and DSR (Dynamic Source Routing) have been developed to find efficient paths between nodes with minimal overhead.

Maintaining connectivity in such fluid environments involves ensuring that nodes can communicate reliably despite frequent changes in their connectivity status. Techniques such as multi-path routing and the use of redundancy can enhance network resilience.

Security in ad hoc networks is addressed through encrypted communication, secure routing protocols, and trust-based mechanisms to protect against various threats, including man-in-the-middle attacks and node impersonation.

Energy conservation is critical in MANETs due to the battery-powered nature of many devices. Strategies include energy-efficient routing protocols that minimize power consumption and techniques for managing the power usage of network devices to extend their operational lifespan.

These solutions collectively aim to enhance the performance, reliability, and security of ad hoc networks, addressing their inherent challenges and making them more viable for a wide range of applications. For a more detailed exploration of these challenges and solutions, I recommend reviewing the comprehensive insights provided in the sources from the Oriental Journal of Computer Science

Bhatt.D & Agrawal.B. (2017). Major challenges of mobile adhoc networks. <https://www.computerscijournal.org/vol10no2/major-challenges-of-mobile-adhoc-networks/>

1. The Adhoc networks has many different real world application. In various different fields like disaster recovery, military, IoT, sensors etc.., One of the applications of Adhoc application is JTRS which is a military application of Adhoc netwrorking.

The JTRS is a Department of Defense initiative, revolutionizes military communications by developing a family of software-programmable tactical radios, ensuring interoperability and wide bandwidth for voice, data, and video communications across the joint battlespace. This initiative directly addresses the limitations of previous systems—namely, their lack of interoperability and insufficient bandwidth for modern military demands. By utilizing a new wideband networked waveform, JTRS facilitates mobile, networked connectivity throughout the battlespace, maintaining compatibility with existing DoD waveforms.

Transitioning to a Programmable, Modular Communications System (PMCS) represents a significant shift from hardware-intensive radios to software-driven solutions for waveform generation, encryption, and signal processing. This approach significantly enhances the flexibility and adaptability of military communications across various environments, from individual soldiers to naval fleets.

The joint service office, with contributions from various military branches, underscores the collaborative effort in developing the JTRS, highlighting its importance as a cornerstone for modern military operations. The involvement of multiple defense agencies in the systems architecture development further illustrates the comprehensive strategy behind the program.

Moreover, the restructuring of the JTRS program to include a Joint Program Executive Office indicates the evolving nature of this initiative, ensuring coordinated development across different radio versions. The selection of multiple contractors to produce PMCS products using common core software and hardware modules underscores the commitment to standardization and interoperability within the defense community (Globalsecurity, 2023).

JTRS's development journey, from addressing inter-service communication challenges in past conflicts to conceptualizing a family of interoperable, scalable, and secure radios, demonstrates the critical role of ad hoc networking in enhancing battlefield communications. This initiative not only provides a template for future military communications systems but also showcases the potential of ad hoc networking to meet complex, evolving operational requirements.

Globalsecurity.(2023). Joint tactical radio system programmable, modular communications system <https://www.globalsecurity.org/military/systems/ground/jtrs.htm>

1. Ad hoc networks, such as wireless ad hoc networks (WANETs), offer a flexible way to connect wireless devices directly without the need for traditional network infrastructure like routers or access points. They can be rapidly deployed and are suitable for situations where infrastructure is unavailable, making them ideal for temporary setups or emergencies. However, managing these networks becomes more complex as they grow, due to challenges like dynamic topology and the need for efficient routing protocols. Solutions include utilizing dynamic and adaptive routing protocols to quickly configure networks and maintain connectivity.

Security in ad hoc networks is a critical concern because they often lack the advanced security features of more traditional networks. Basic security measures can be implemented, but the temporary and dynamic nature of these networks can limit their effectiveness. Ensuring secure communication in such networks requires balancing the ease of setup and the inherent security risks, with measures like WPA-Personal for encryption.

Despite their limitations, ad hoc networks remain valuable for specific use cases, such as temporary network setups, emergencies, or when infrastructure is not feasible. They offer a quick and cost-effective method for device-to-device communication, but their scalability, performance, and security aspects must be carefully considered.

1. Ad hoc networks, characterized by their flexibility, self-configuring capabilities, and lack of fixed infrastructure, have found significant application across various fields. Each of these applications leverages the unique strengths of ad hoc networking to address specific challenges, demonstrating the versatility and potential of these networks in real-world scenarios.

**Disaster Recovery:** Ad hoc networks play a critical role in disaster recovery operations. In environments where traditional communication infrastructure is damaged or unavailable, mobile ad hoc networks (MANETs) can be rapidly deployed to establish communication among rescue teams, survivors, and command centers. The self-configuring nature of these networks allows for:

* Quick setup and teardown, adapting to the dynamic conditions of a disaster zone.
* Reliable communication even in areas with no pre-existing infrastructure, enabling effective coordination of rescue efforts and dissemination of critical information.
* Increased resilience against network failures, as nodes can dynamically reconfigure to maintain connectivity.

**Military Operations**: In the context of military operations, ad hoc networks offer strategic advantages due to their robustness and flexibility. Operations often occur in environments lacking in communication infrastructure, or where existing infrastructure is compromised. Military applications of MANETs and vehicular ad hoc networks (VANETs) include:

* Secure and reliable communication between units in dynamic battlefield conditions, enhancing situational awareness and operational coordination.
* The use of unmanned aerial vehicles (UAVs) and ground units forming ad hoc networks to gather and relay reconnaissance information, improving decision-making and tactical planning.
* Integration with advanced technologies like artificial intelligence for intelligent vehicular ad hoc networks (InVANETs), enhancing vehicle-to-vehicle (V2V) communication for autonomous operations and convoy coordination.

**Internet of Things (IoT) Implementations**: IoT applications greatly benefit from the decentralized nature of ad hoc networks, particularly in smart cities, agricultural monitoring, and environmental sensing. These networks facilitate:

* Scalable and flexible connectivity among a vast number of sensors and devices, enabling real-time data collection and monitoring without the need for centralized control.
* Energy-efficient communication protocols in MANETs, crucial for battery-operated sensors and devices, extending their operational lifespan.
* Enhanced coverage and reliability in monitoring applications, with the ability to operate in challenging environments like remote agricultural lands or dense urban areas, providing critical data for decision-making.

The practical applications of ad hoc networks across these diverse fields underscore their ability to leverage key strengths such as flexibility, resilience, and decentralized operation. By enabling reliable communication and connectivity in scenarios where traditional networks are impractical or unavailable, ad hoc networking technologies continue to expand their impact, driving innovations and improvements in disaster recovery, military operations, and IoT implementations

Reference: <https://www.tutorialspoint.com/applications-of-adhoc-network-and-its-problem>