

CMSC 628 – Spring 2019

Introduction to Mobile Networks

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CMSC 628- Mobile Networks



VCU

School of Engineering | Computer Science

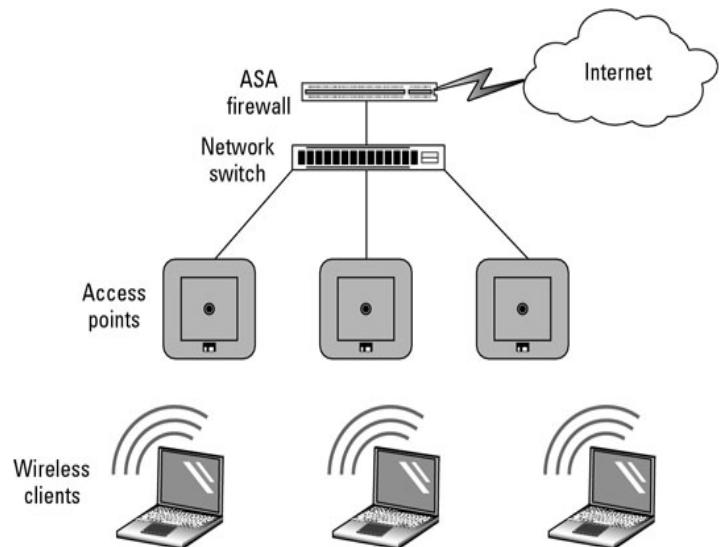
Mobile Communication World

- Proliferation of mobile computing and communication devices starting late 90s
 - ❖ Cell phones, laptops
 - ❖ Handheld digital devices
 - ❖ Personal Digital Assistants (PDA)
 - ❖ Wearable computers
- WiFi hot spots replaced wired access networks



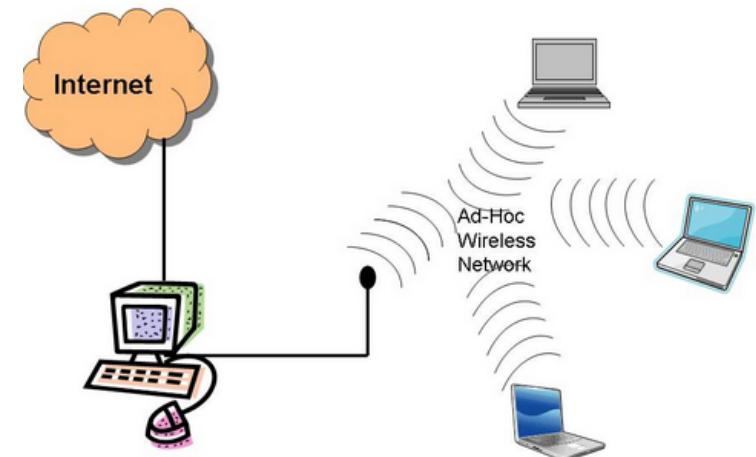
Infrastructure Networks

- Devices on the network all communicate through an access point: a device that allows wireless devices to connect to a wired network using Wi-Fi
- Challenges:
 - ❖ it takes time and potentially high cost to set up the necessary infrastructure everywhere.
 - ❖ Not works for dynamic environments
 - E.g. rural or disaster areas



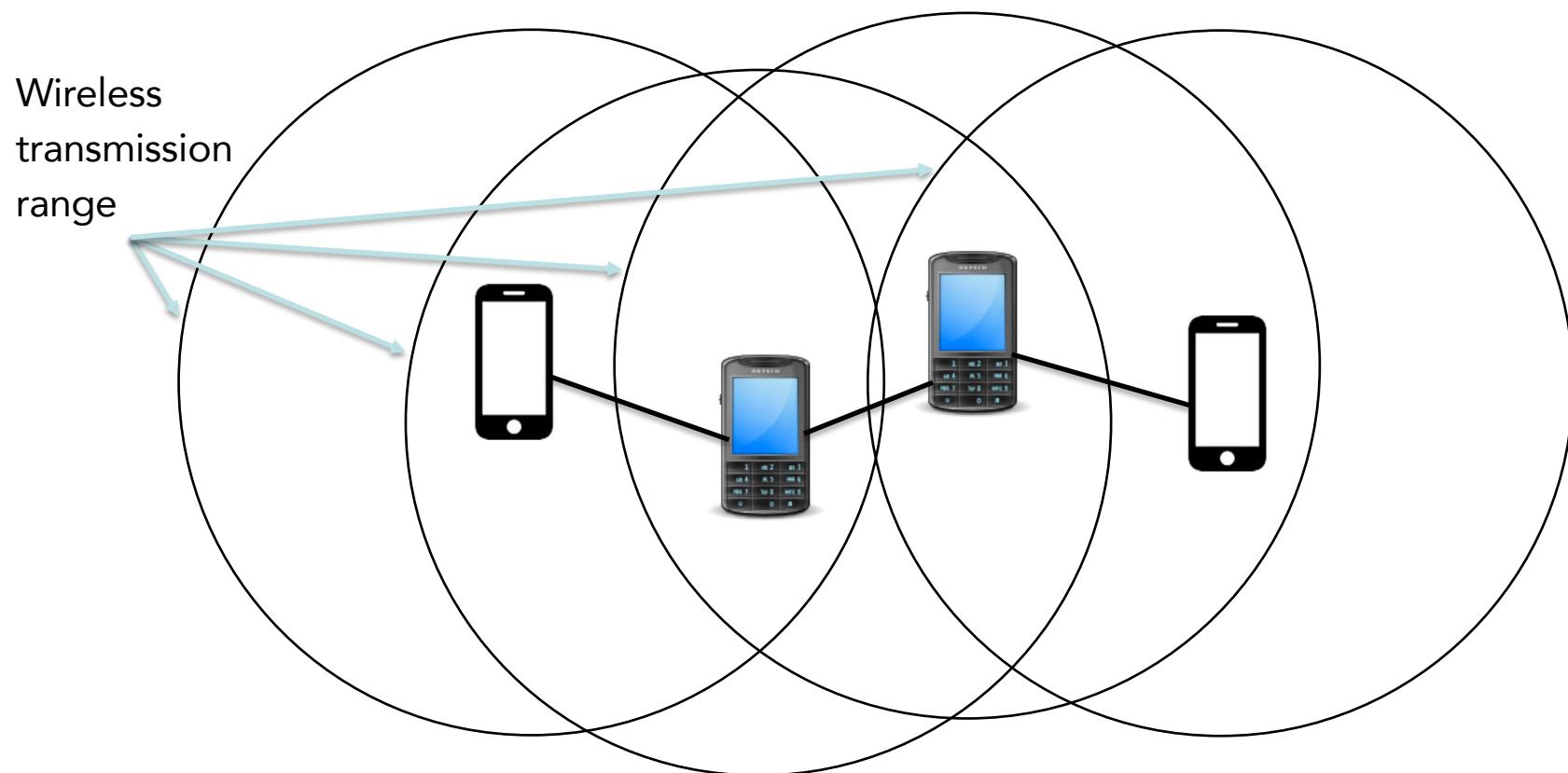
Infrastructure-Less Networks

- Decentralized type of wireless network
- Self organizing or Infrastructure-less
- It does not rely on
 - ❖ preexisting infrastructure such as routers in wired networks
 - ❖ access points in wireless networks
- The wireless network nodes (e.g., the users' mobile devices) communicate with each other to perform data transfer
- Nearby users can communicate directly by exploiting the wireless technologies of their devices in ad hoc mode



Mobile (Ad hoc) Networks (MANET)

- Ad-hoc means '*for this purpose*'
 - ❖ used to describe something that has been formed or used for a special and immediate purpose, without previous planning.
- Self organizing networks (SON)

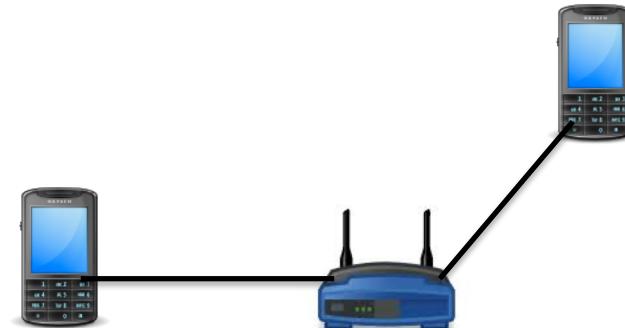


Mobile Ad hoc Network (MANET)

- Each device is free to move independently in any direction, and will therefore change its links to other devices frequently
 - ❖ Hence, it has a **dynamic topology**
- The primary challenge in building a MANET is equipping each device to continuously maintain the information required to properly **route traffic**

MANET forms

- Single-hop
 - ❖ Simplest form
 - ❖ Direct connectivity
- Multi-hop
 - ❖ MANETs often refer to this form of connectivity



Challenges

- **Infrastructure-less design** adds difficulty in fault detection and management
- **Dynamic topology** results in route changes and packet loss
- **Scalability** is still unsolved, challenges include addressing, routing, configuration management, interoperability, etc.
- **Varied link/node capabilities** cause variable processing capabilities
- **Energy constraints** limit processing power; ad-hoc networks rely on each node being a “router”

Applications of MANETs

- Advantages: low-cost, flexibility
 - ❖ Ease & Speed of deployment
 - ❖ Decreased dependence on infrastructure
- Applications
 - ❖ Military environments
 - soldiers, tanks, planes
 - ❖ Civilian environments
 - vehicle networks
 - conferences / stadiums
 - outside activities
 - ❖ Emergency operations and disaster scenarios
 - search-and-rescue / policing and fire fighting

MANET History

- In 2000-2005, MANET was one of the most innovative and challenging areas of wireless networking
 - ❖ Numerous research efforts
- Today, the promise of ad hoc networking never fully realized, and that MANET solutions are not used in people's life
 - ❖ A few practical deployments
 - FireChat, Serval Project
 - ❖ Reasons:
 - Lack of real approaches/objectives in research
 - Only theoretical parts of interesting research questions studied
 - Mostly simulation based evaluation without real experiments

MANET Research

➤ Focus:

- ❖ Mostly focused on general purpose pure MANET
 - No specific application
- ❖ Aimed to extend Internet services to non-infrastructure areas
- ❖ A complete redesign of network architecture and protocols
- ❖ Efficient communication algorithms
- ❖ Standardization efforts through IETF MANET Working Group
 - IETF = Internet Engineering Task Force

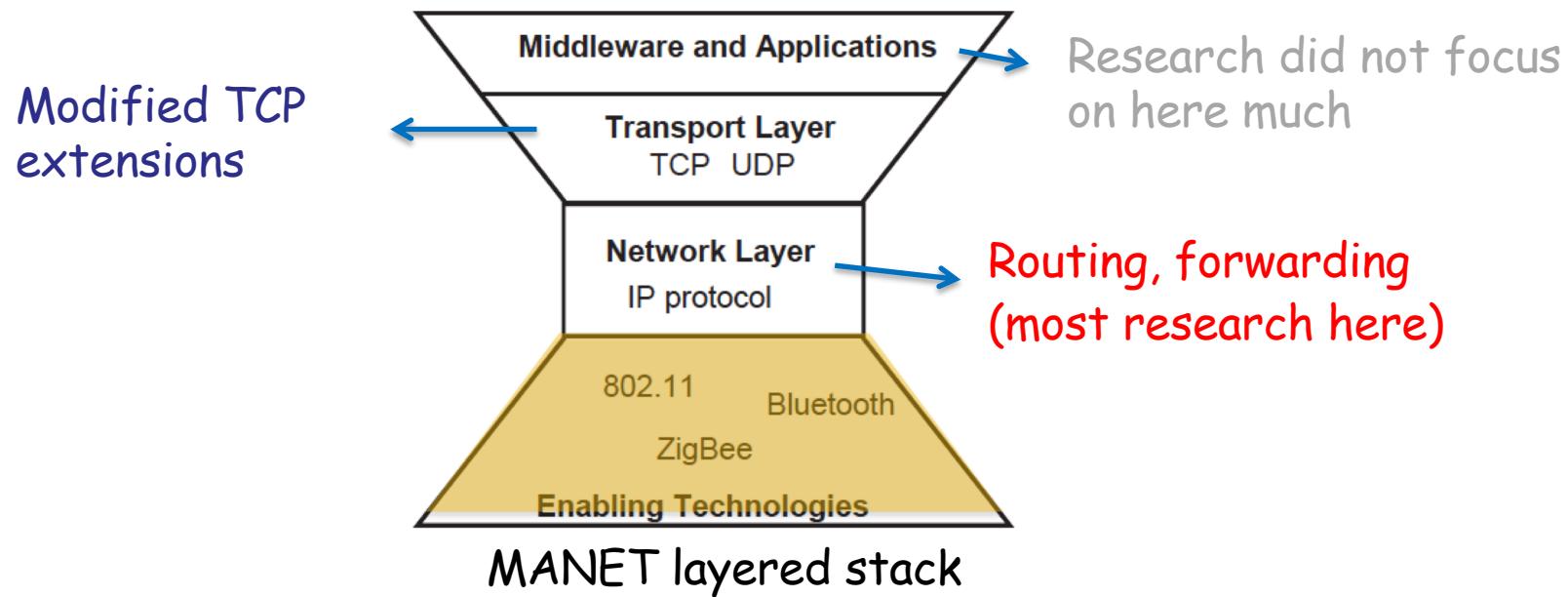
IETF MANET Working Group

<https://datatracker.ietf.org/wg/manet/about/>

"The purpose of the MANET working group is to standardize IP routing protocol functionality suitable for wireless routing applications within both static and dynamic topologies with increased dynamics due to node motion or other factors."

"Approaches are intended to be relatively lightweight in nature, suitable for multiple hardware and wireless environments, and address scenarios where MANETs are deployed at the edges of an IP infrastructure."

MANET Layers



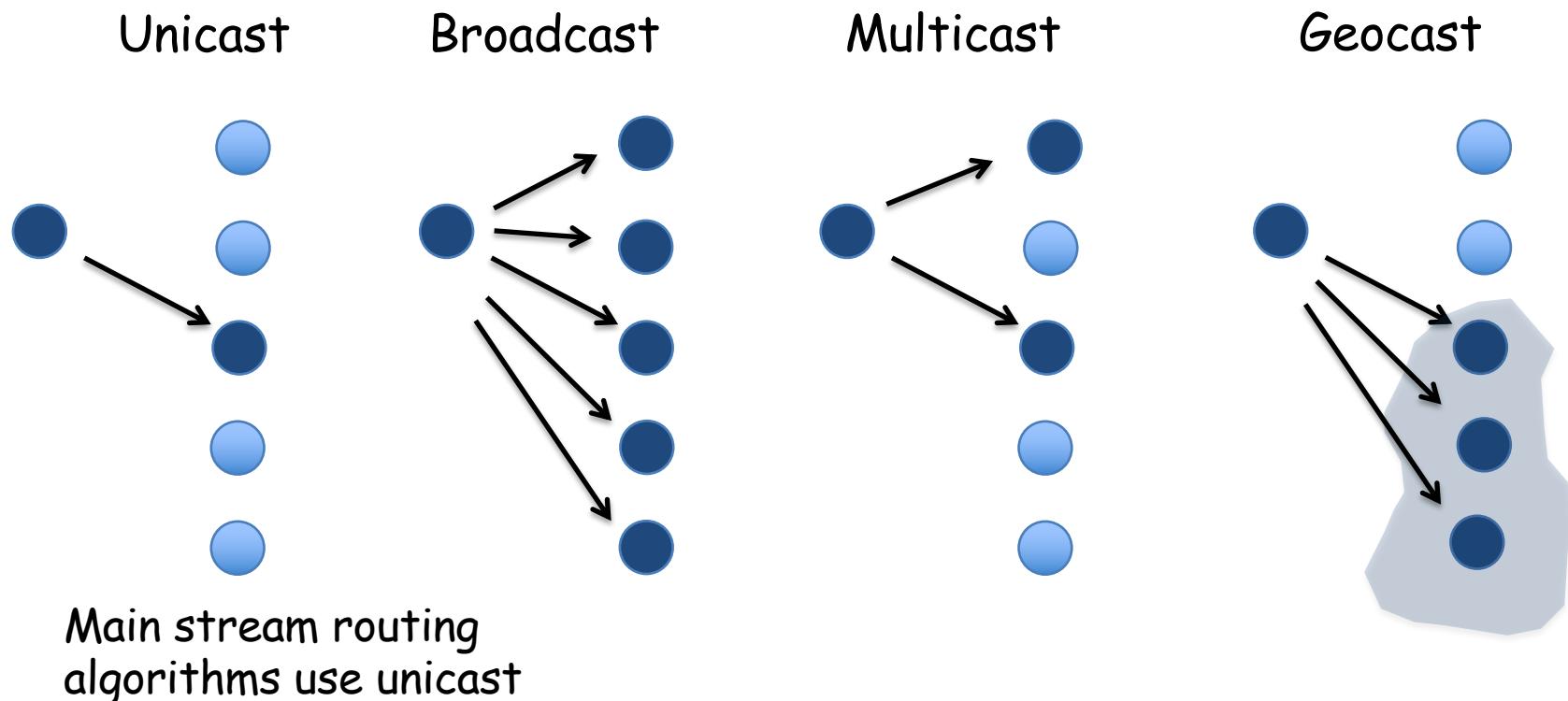
+ Cross-layer research issues

MANET Networking Layer

- **Routing:** identifying the path between a sender and a receiver
- **Forwarding:** The subsequent function of delivering the packets on the routing path
- Legacy wired network based routing problems do not work due to dynamic and unpredictable nature of MANET topology
- MANET routing protocols have the following common features. They aim to
 - ❖ discover a path from source to destination
 - ❖ maintain that path (e.g., if an intermediate node moves and breaks the path)
 - ❖ define mechanisms to exchange routing information

MANET Casting

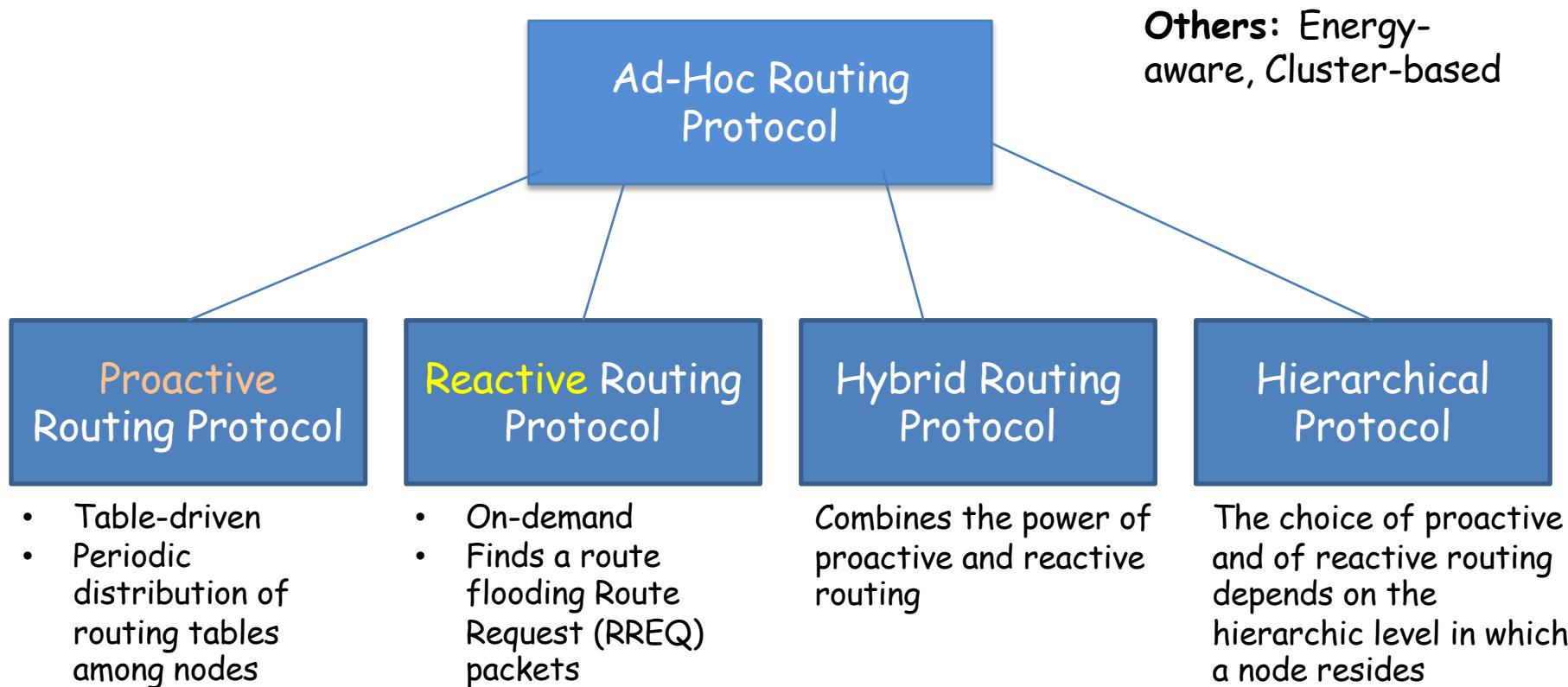
- Routing protocols can be defined based on different casting approaches:



MANET Routing Challenges

- Routing overhead must be kept minimal
 - ❖ Wireless → low bandwidth
 - ❖ Mobile → low power
 - ❖ Minimize # of routing control messages
 - ❖ Minimize routing state at each node
- Nodes must determine how to forward packets
 - ❖ Source routing: Routing decision is made at the sender
 - ❖ Hop-by-hop routing: Routing decision is made at each intermediate node
- Difficult to achieve good performance
 - ❖ Routes change over time due to node mobility
 - ❖ Best to avoid long delays when first sending packets
 - ❖ Best to reduce overhead of route discovery and maintenance
 - ❖ Want to involve as many nodes as possible - to find better paths and reduce likelihood of partitions

MANET Routing Protocols

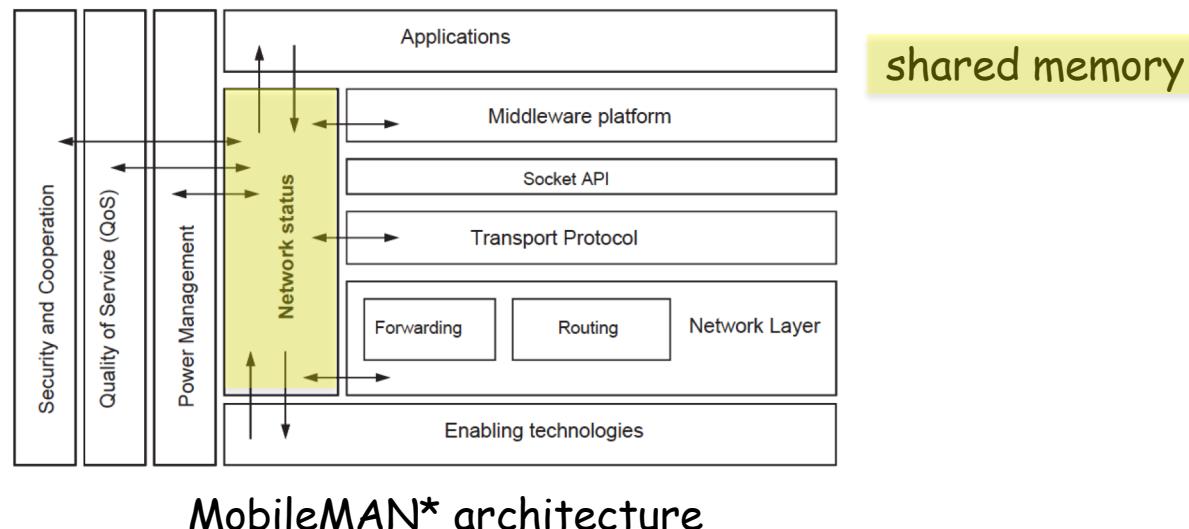


Cross-Layer MANET Research

- Some issues are not specific to a single layer:
 - Energy efficiency
 - Local and global strategies
 - Should consider both individual node energy and its impacts to the network
 - Always sleeping node without contributing to routing is not a good one
 - Topology control (via sleep scheduling, controlling the transmission power) without compromising coverage is a good one
 - Security
 - Malicious nodes can disrupt the proper functioning of routing (e.g., false routing tables)
 - Cooperation
 - Incentives for collaboration, to avoid selfishness
 - Virtual currency (paid for transmission, reward when forwarding others)

Cross Layer Architecture

- Interlayer Communications
 - ❖ Additional communication channels between different layers
- Interlayer Tuning
 - ❖ Joint optimization of each independent layer
- Interlayer Design
 - ❖ Joint design of two (or more) layers.
- Unlayered Design



*Borgia et. al., MobileMAN: Design, integration, and experimentation of cross-layer mobile multihop ad hoc networks, IEEE Communications Magazine, 2006.

Evolution of MANET

- Why the MANET paradigm did not have a major impact?
What are the lessons learned?
 - ❖ Originally it was military research driven and could not make shift to civilian applications
 - Limited off-the-shelf wireless network technologies
 - ❖ Academia focused on interesting problems
 - ❖ Scarce exploitation and low interest among the users
 - ❖ Limited simulations and less credibility due to lack of implementation, integration and experimentation except a few (MobileMAN, Uppsala APE testbed, Dartmouth College testbed)

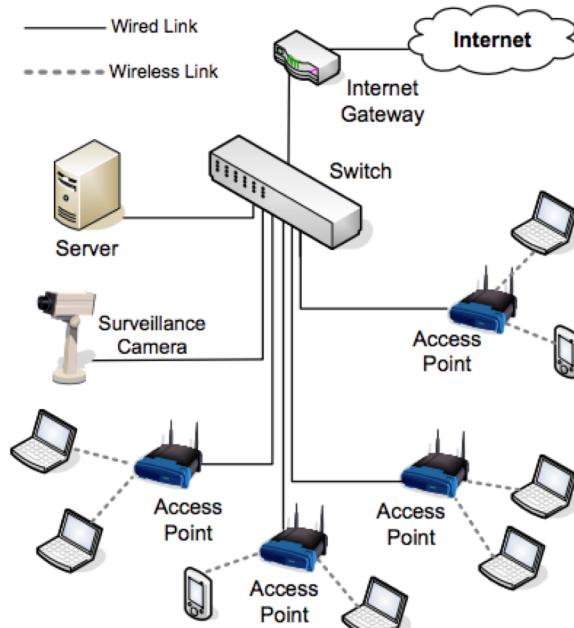
From MANET to...

➤ What are the new technologies emerged from MANET?

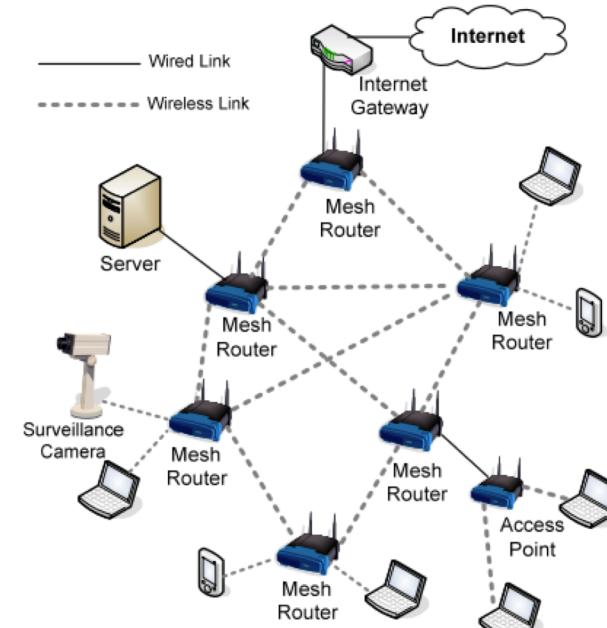
- Mesh networks (integrated to infrastructure)
- Opportunistic networks
 - Mobility as opportunity not a problem
- Application focused
 - Wireless Sensor Networks (IoT Networks)
 - Vehicular Networks

Mesh Networks

- Aims to reduce the MANET complexities with integration of fixed networks
- Low-cost extension of Internet with a few hop wireless links
- Research has focused on all of implementation, integration and experiments on real networks with real users



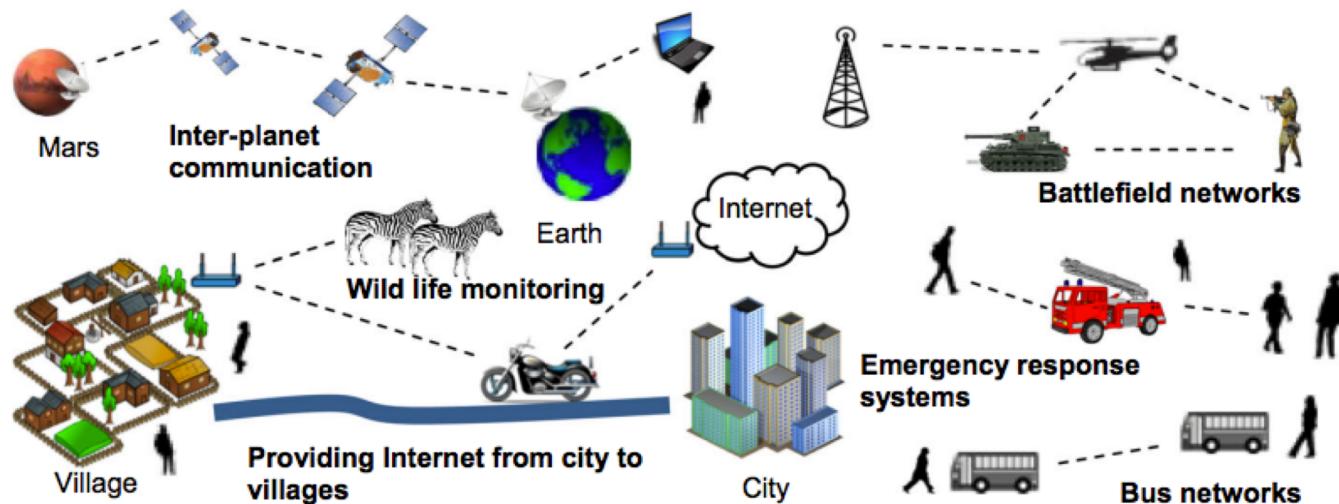
Traditional WLAN



Mesh Network

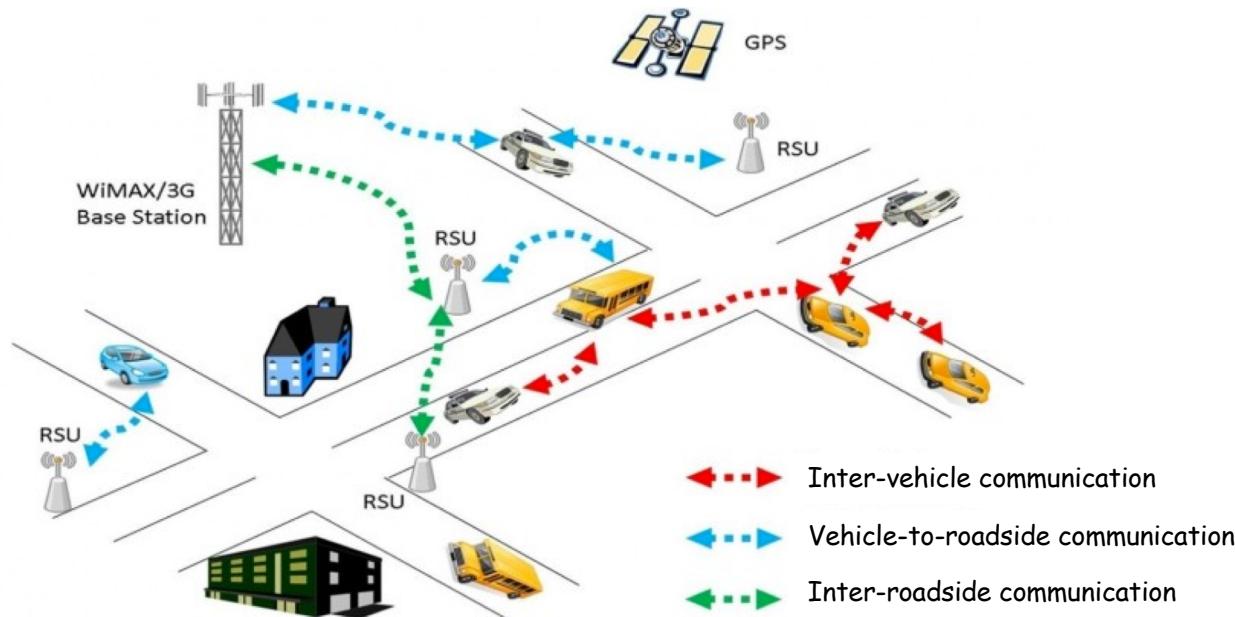
Opportunistic Networks

- Delay tolerant networks (DTN), Intermittently Connected Networks
- Characteristics:
 - ❖ No stable end-to-end path
 - ❖ Store-carry-and-forward paradigm for routing
 - Mobility not a problem but opportunity
- Challenges:
 - ❖ Online decision making
 - ❖ Mobility understanding and modeling (e.g., inter-contact distribution)



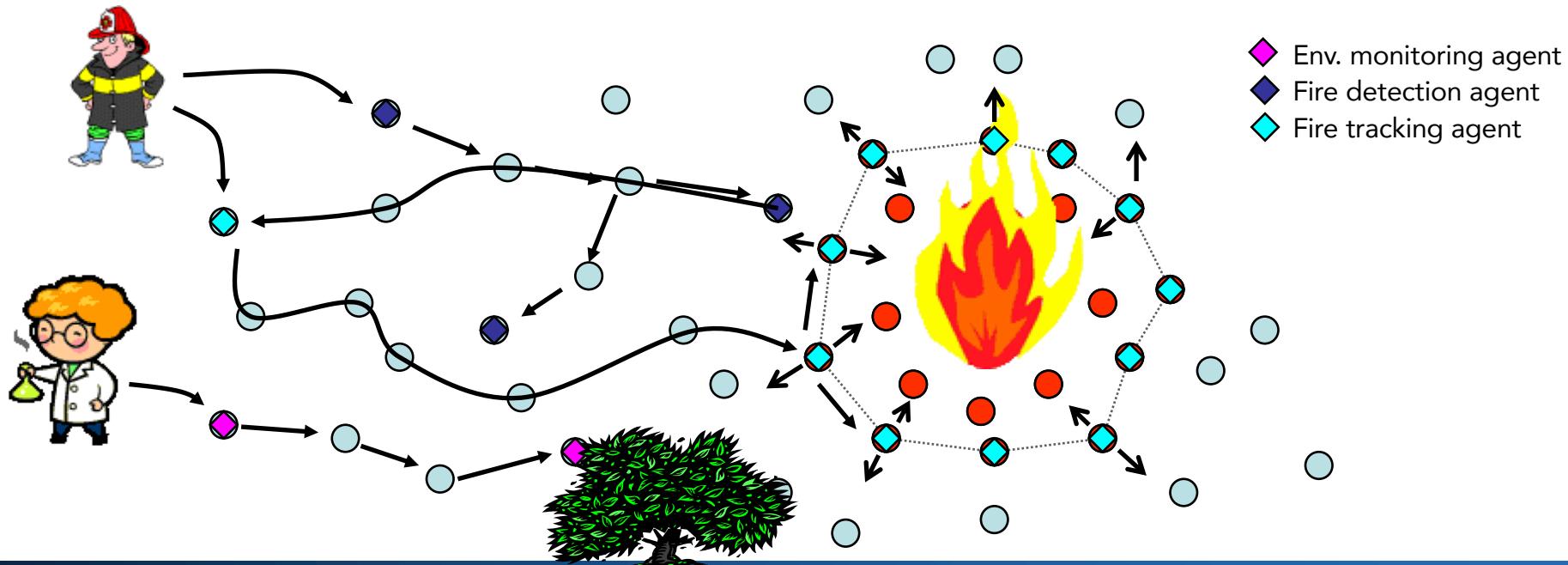
Vehicular Ad Hoc Networks (VANETs)

- Motivated by Intelligent Transportation System (ITS) goals
 - ❖ Reducing traffic congestions, road accidents..
- Peculiar features of vehicular field
 - ❖ Road structure, high speeds etc.
 - ❖ New communication protocols: WAVE, DSRC



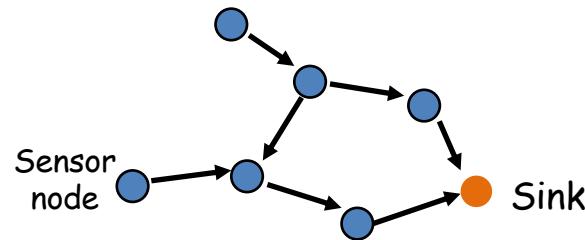
Wireless Sensor Networks (WSN)

- Sensor and actuator networks (Cyber and physical components)
 - Data collection at sink, stable & mobile sensors, message ferries/robots
 - Extensive research done on:
 - ❖ Topology control, energy saving, clock synch, coverage, connectivity, routing, MAC protocols
 - Limited unstudied topics:
 - ❖ Security/trust, Quality of service, realistic simulations, underwater sensor networks
 - New extensions: Human-centric (mobile) sensing/computing, participatory sensing

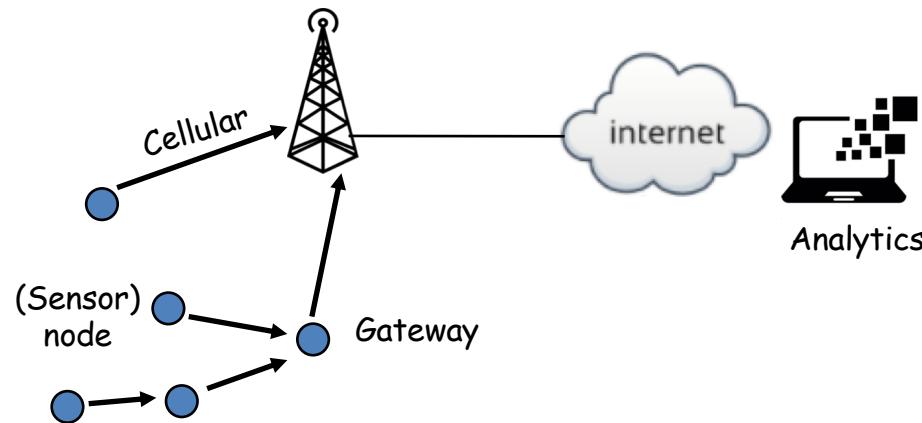


WSN vs. IoT

- WSN: a set of sensors that send their data to a sink, not necessarily connected to Internet



- IoT: a set of (sensor) nodes that are connected to Internet (and cloud for analytics) either directly or via a gateway



What's next?

- Next class: Enabling Technologies for Mobile Networks
- MANET:
 - ❖ Medium Access Control (MAC)
 - ❖ Routing Protocols
- Opportunistic networks
 - ❖ Routing algorithms, Mobility modeling, Analysis
- Wireless Sensor Networks (IoT Networks)
- Vehicular Networks