

# **An Overview of Mobile Ad hoc Networking**

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# Overview of Presentation

- **Introduction to MANET**
- **Applications for MANET**
- **IP-based MANET Control Rationale**
- **IETF Standardization Work Status**

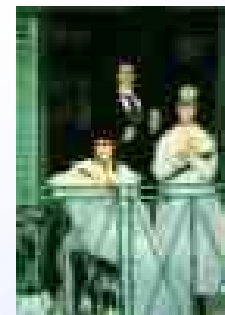
# MANET (1832-1883)



Edouard Manet

**“Father of Impressionism”  
whose work influenced**

- **Edgar Degas**
- **Claude Monet**
- **Auguste Renoir**
- **Alfred Sisley**
- **Camille Pissarro**
- **Paul Cézanne**

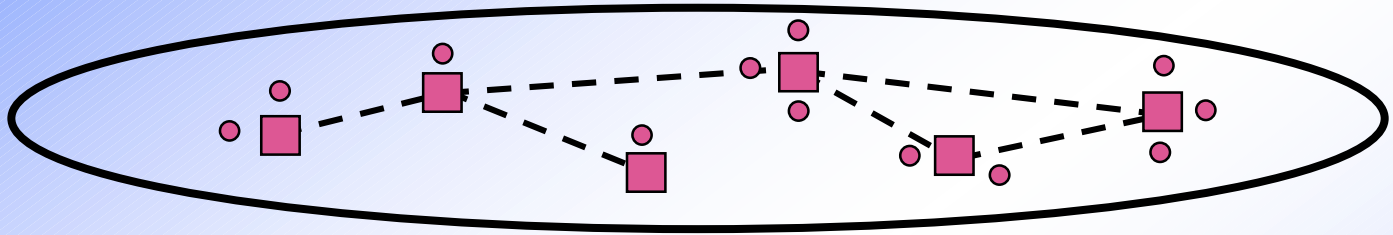


# Mobile Ad Hoc Networking

## *Technology also known as ...*

- **Mobile Packet Radio Networking**
  - ▲ Term coined during early military research (70s, 80s)
- **Mobile Mesh Networking**
  - ▲ Term which appeared in an *Economist* article regarding the structure of future military networks
- **Mobile, Multihop, Wireless Networking**
  - ▲ Perhaps the most accurate term

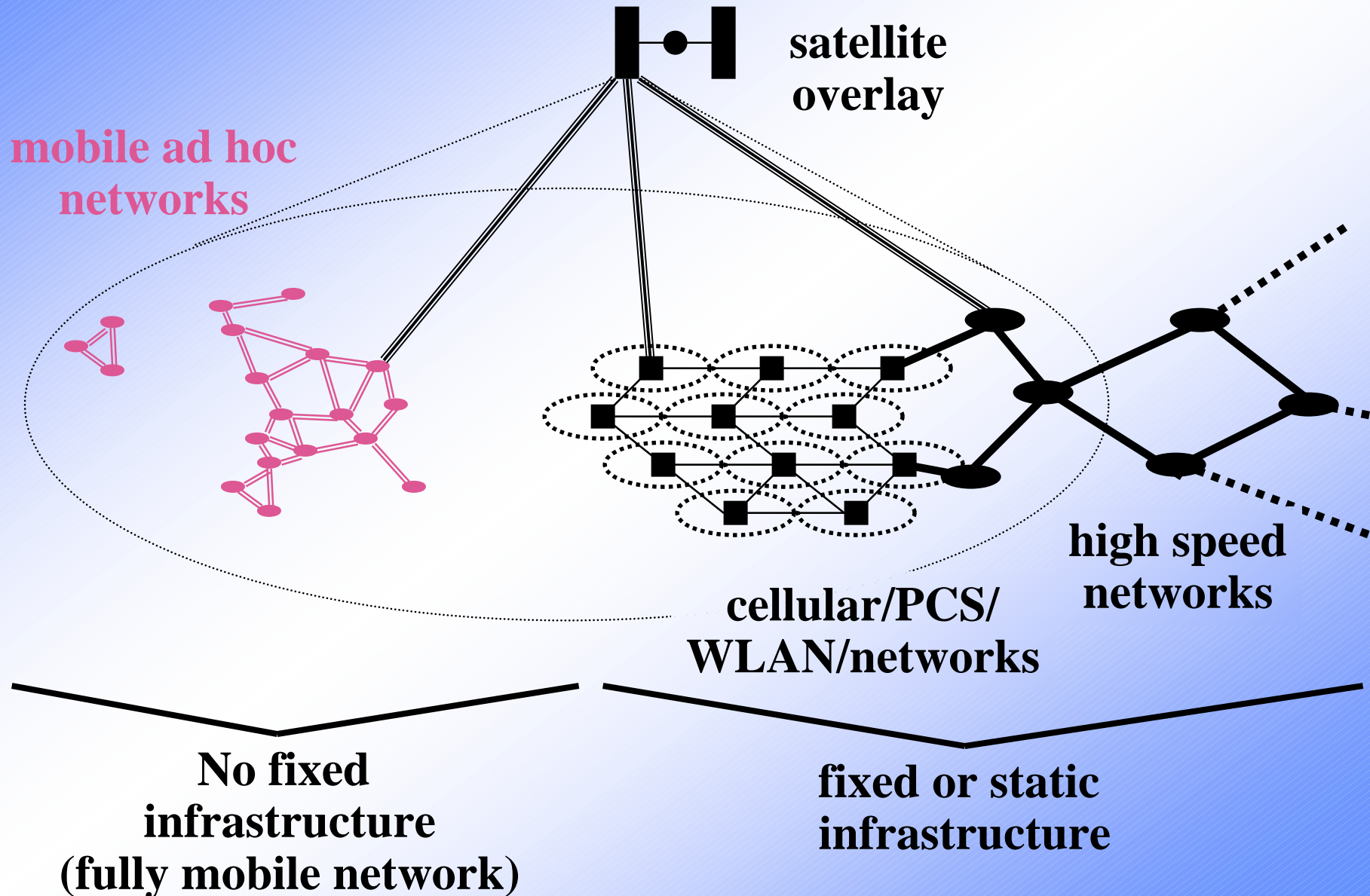
# Characteristics of MANET Technology



## *Mobile Ad hoc Networks (MANET)*

- *No wires or cabling (cheap installation)*
- *Mobile infrastructure possible (flexible)*
- *Autonomous operation possible (stand-alone)*
- *Relatively low capacity (Mbps)*

# Hybrid Communications Networks



# Likely Initial Usages

↪ Small-scale (few nodes)

↪ Usage in Diverse Applications

- Commercial
  - Industrial: factory, construction site, outdoors
  - Office/Home: personal networks
- Government-specific
  - Fire/Safety/Rescue/Disaster Recovery operations
  - Military
- Community/Urban Networks (HAM radio-type)
  - “covert” networks

# Farther Term Usage

## ↳ Large-scale usage (many nodes)

- Commercial
  - Mobile Cellular-like Infrastructures
- Government
  - Large-scale Military Networks
- “Free” Community/Urban Networks
  - Unrestricted local communications



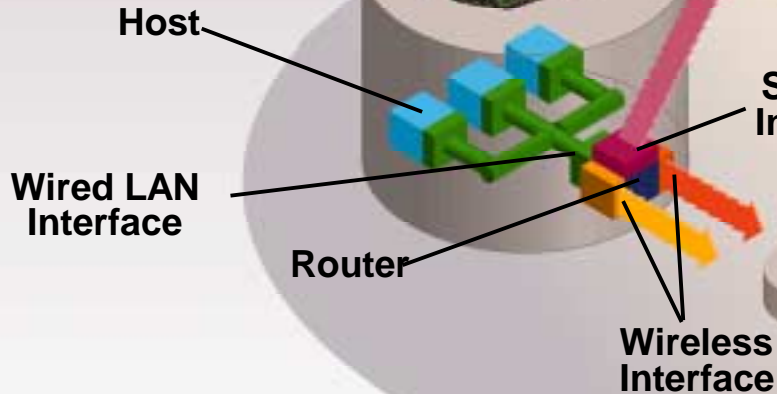
# MANET: A network of highly mobile platforms that are not dependent on pre-existing or fixed communications infrastructure

Airborne router provides asymmetric links to MANET

Embedded host/router with single wireless interface

Router connects hardwired local net to multiple wireless interfaces

Combined host/router with multiple wireless interfaces



Satellite Interface

Ad hoc networks form and disband as mobile nodes enter and exit net



# Initial Architectures

- **Low power sensor networks**
  - \* **“Surveillance” webs**
- **Small, relatively static, embedded ad hoc networks**
  - \* **“Bluetooth-type” networks**
- **Small-to-medium sized, mobile ad hoc networks**
  - \* **“802.11-style” networks**

## ↪ A Wireless LAN (WLAN) Standard

- 2.4 GHz, 1 to 11 Mbps WLAN technology capable of efficient multihop operation using peer-to-peer CSMA/CA mediated access
- Range: nominal 250 meters, but extendable with power amplification
- Suitable for in-building and outdoor usage
- Cost: \$100's per transceiver, possibly \$10's per transceiver in future

# 802.11 Uses

## ↪ Campus-sized networks

- people
- vehicles

## ↪ Voice over IP over MANET over 802.11

- peer-to-peer
  - point-to-point
  - multi-hop
- non-optimized---yet works good enough as long as network loading is low

# Bluetooth

↪ A global specification for wireless connectivity created by an industry consortium

- “cable replacement” technology
- 2.4 GHz, 1 Mbps wireless LAN technology capable of multihop operation
- Short Range: 10m initial range (100m coming)
- Suitable for in-building and personal use
- Cost: \$5 per transceiver chip targeted

# Bluetooth Uses

## ↳ Personal Networks

- cellphone to laptop (in briefcase ;-), ...

## ↳ Desktop Networks

- between laptop, desktop, printer, fax, network

## ↳ Spontaneous Networks

- ad hoc meetings, laptop to laptop
- conferences

# Technology keeps Changing...

- ↪ Wireless technologies will continue to *evolve*
- ↪ Multiple technologies can be used *simultaneously--multi-mode radios*
  - There is need for a *standards-based* approach at the network layer

# **Mobile Ad hoc Networking and the Internet Engineering Task Force (IETF)**

<http://www.ietf.org/html.charters/manet-charter.html>

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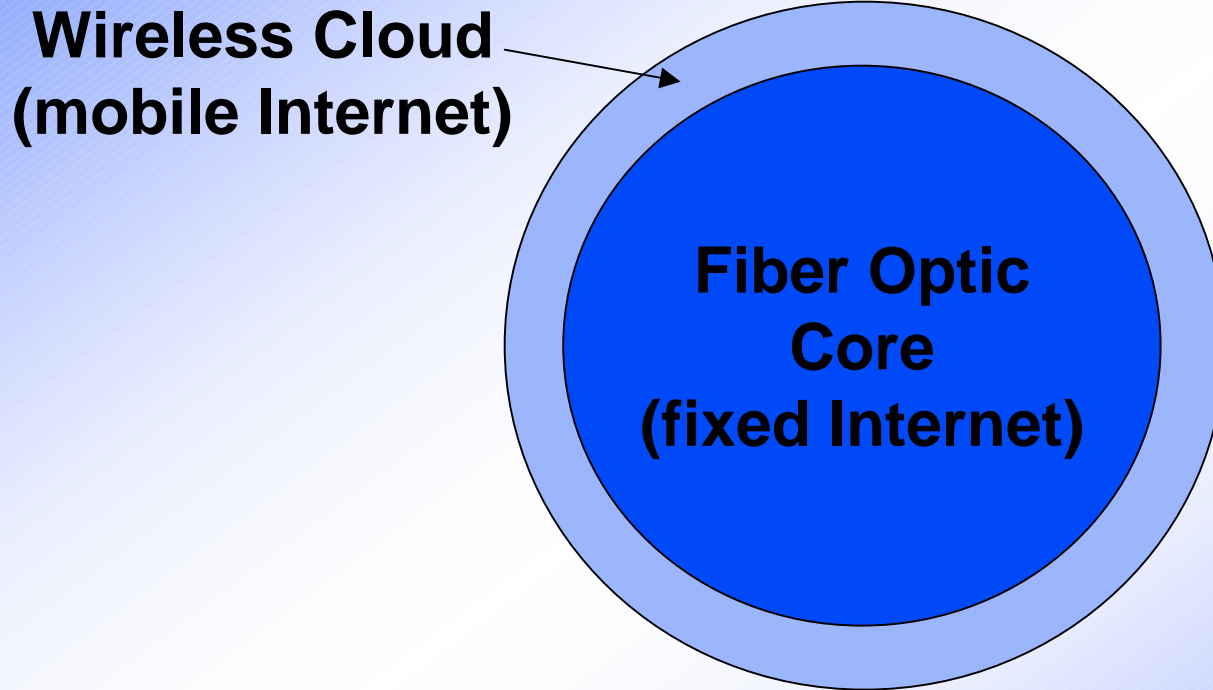
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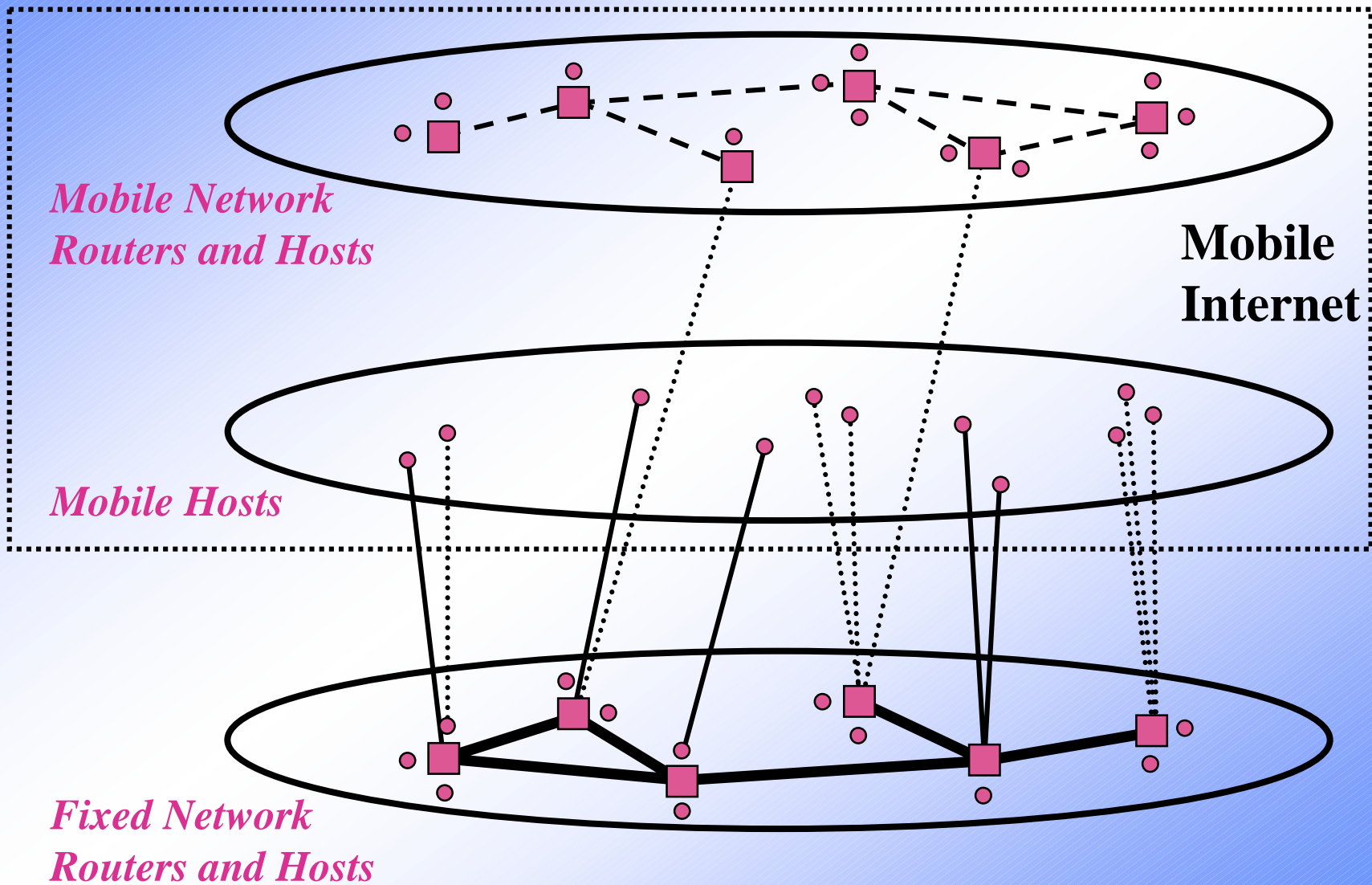
**Information Technology Division**  
Code 5540  
Naval Research Laboratory  
Washington, D.C. 20375



# Future Global Internet Architecture



# The Emerging Mobile Internet



# Mobile Ad Hoc Networking (MANET)

## *Characteristics*

- **Dynamic topologies**
- ***Bandwidth-constrained, variable capacity, asymmetric links***
- ***Energy-constrained operation***
- **Wireless vulnerabilities and limited physical security**

# Advantages of IP Routing for MANETs

## *Traditional Mobile Packet Radio Design*

- Proprietary
- Single technology
- Technology-specific networking

## *IP-Based Design*

- Standards-based
- Degree of physical media independence
- Routing flexibility, efficiency and robustness
- Eased interoperability with Internet
- Hardware economies of scale
- Future quality of service support

# Why an Internet Layer Solution?

(... as opposed to subnet-based, link-level addressing and routing)

- The intent is the same as the original concept of the Internet:

*“... to develop a homogeneous networking capability over a heterogeneous networking infrastructure.”*

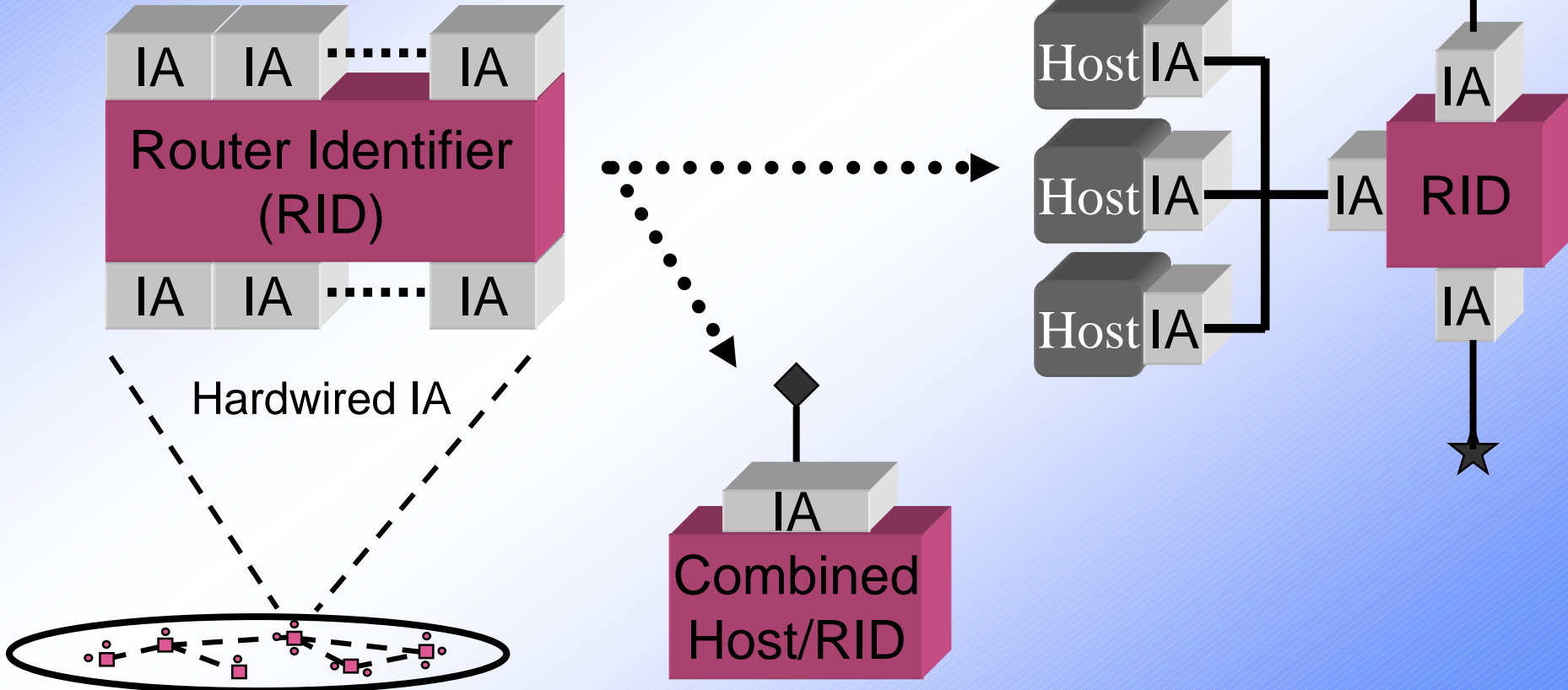
**Commercial Driver-> Cost Effectiveness**

- In this case, the infrastructure is wireless rather than hardwired with
  - ▲ *Multiple* wireless platforms
  - ▲ *Multiple* link-layer technologies

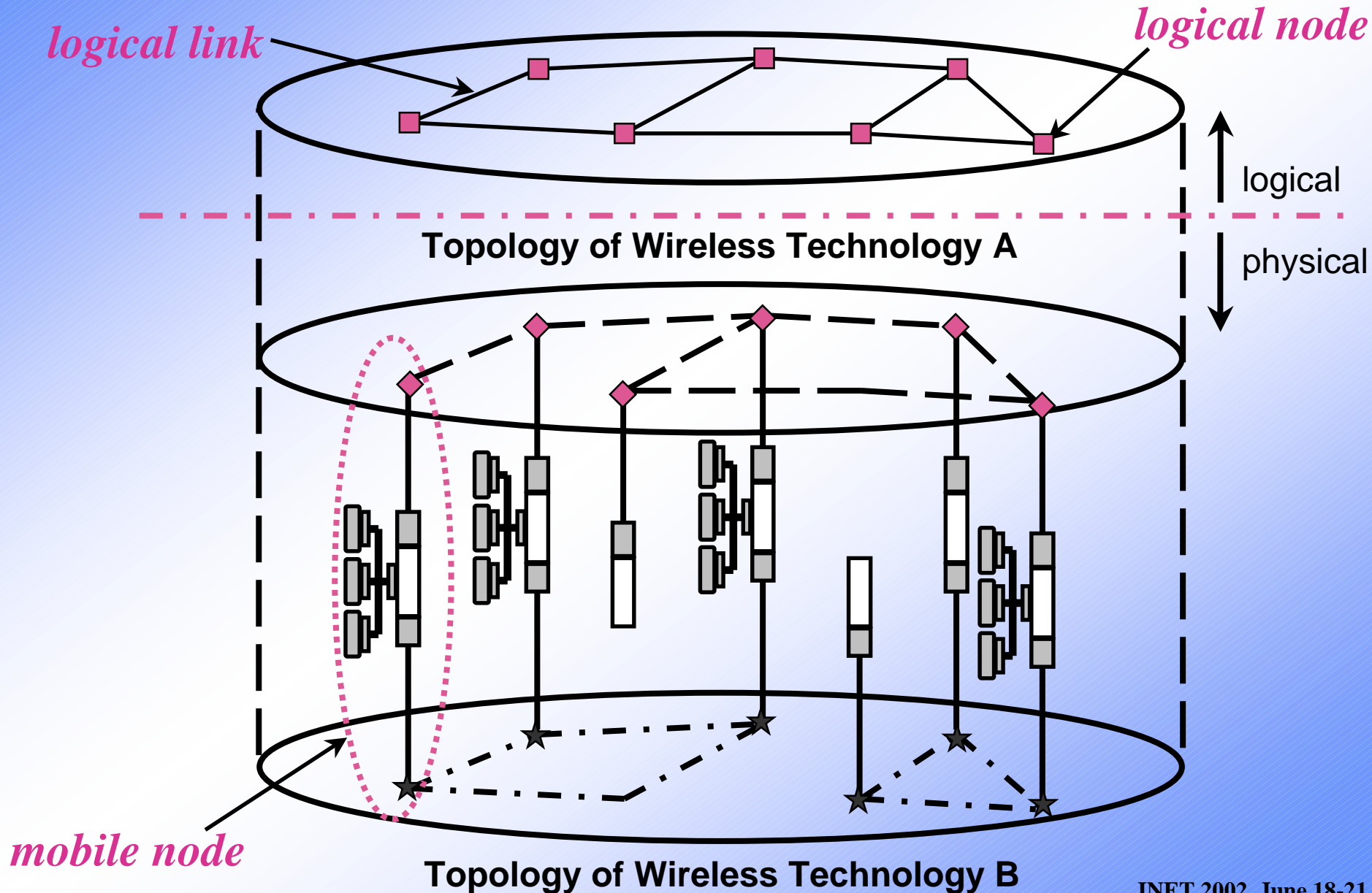
# Generic MANET Router Structure

**MANET:** An autonomous system of mobile nodes which may consist of separate networked devices or may be integrated into a single device

Wireless Interface Address (IA)



# Logical Topology of Wireless Fabric for Routing at the IP Layer



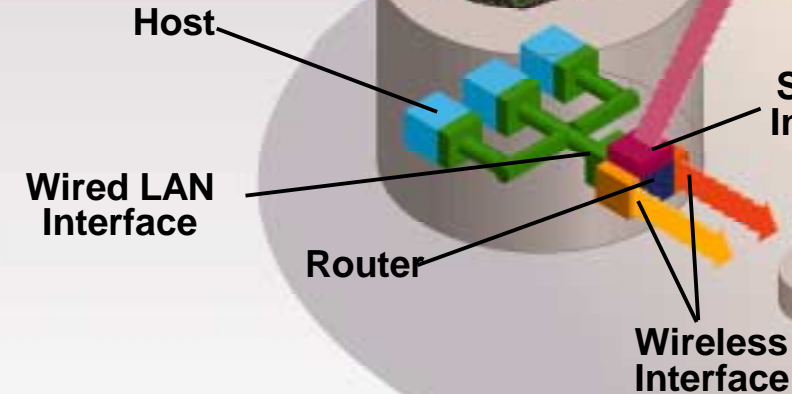
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# Application to Today's Networking

*IP-based MANET can provide robust, low-capacity communications*

- Secondary form of information delivery
- Primary form when higher capacity options are unavailable

*Advantages include:*

- Cost effectiveness
- Flexibility
- Interoperability
- Physical media independence

# IETF Proposed Algorithms

*“One size does not fit all...”*

## *Smaller Networks*

- Ad hoc On-demand Distance Vector (AODV)
- Dynamic Source Routing (DSR)
- Optimized Link State Routing (OLSR)
- Topology-Based Reverse Path Forwarding (TBRPF)

## *Larger Networks*

- Temporally-Ordered Routing Algorithm (TORA)
- Zone Routing Protocol (ZRP)
- Landmark Router (LANMAR)

# IETF Standards Snapshot

- ↪ **AODV: completed second WG last call for comments on promotion to Experimental RFC status**
- ↪ **DSR: second last call coming**
- ↪ **OLSR and TBRPF: respective proponents are engaged in a debate within the WG for mindshare**
- ↪ **Large-scale MANETs: Near-term impracticality and lack of WG interest have put this work into question**
- ↪ **Flooding: work beginning on requirements definition**

# Questions???

For More Information...

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**[http://tonnant.itd.nrl.navy.mil/manet/manet\\_home.html](http://tonnant.itd.nrl.navy.mil/manet/manet_home.html)**