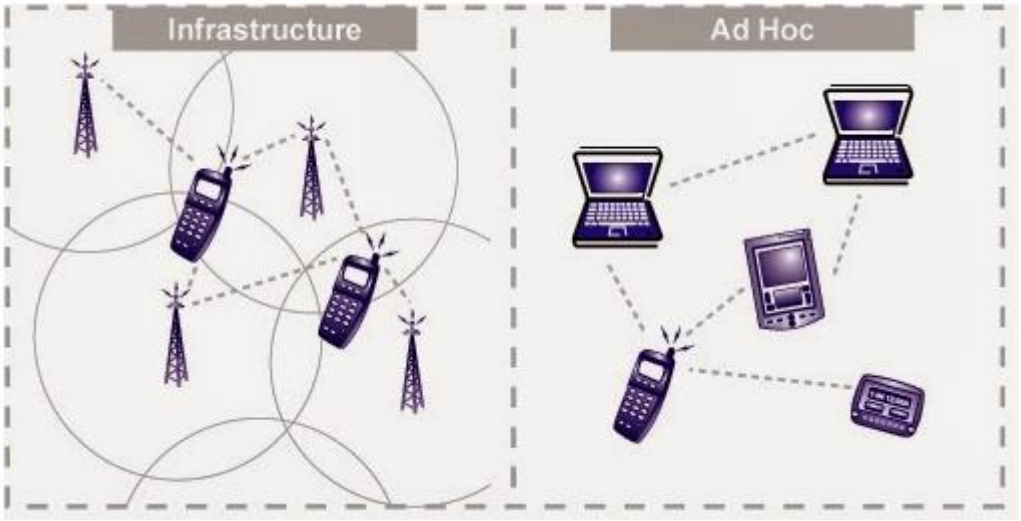
Ad Hoc and Sensor Networks

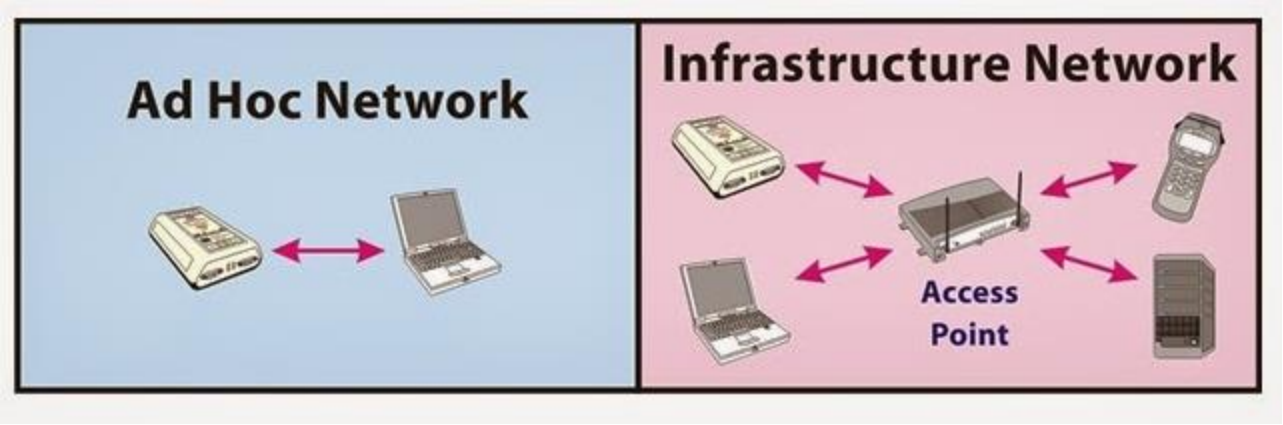
Definition

"It is an autonomous system of mobile hosts(MHs)(also serving as routers) connected by wireless links."

Ad Hoc networks do not need support from any existing infrastructure, like Base Station, Access Point, etc.

Ad Hoc Model


Infrastructure
Ad Hoc


Ad Hoc Network
Infrastructure Network
Access
Point

Infrastructure Vs Ad Hoc Network

Infrastructure networks	Ad-hoc wireless networks
Fixed infrastructure	No infrastructure
Single-hop wireless links	Multi-hop wireless links
High cost and time of deployment	Very quick and cost-effective
Reuse of frequency via channel reuse	Dynamic frequency sharing
Nowadays applications: civilian, commercial	Nowadays applications: military, rescue
High cost of network maintenance	Maintenance operations are built-in
Low complexity of mobile devices	Intelligent mobile devices are required
Widely deployed, evolves	Still under development in commercial sector

What makes ad hoc so attractive:

- quick deployment;
- inexpensive deployment and operation.

Technical challenges

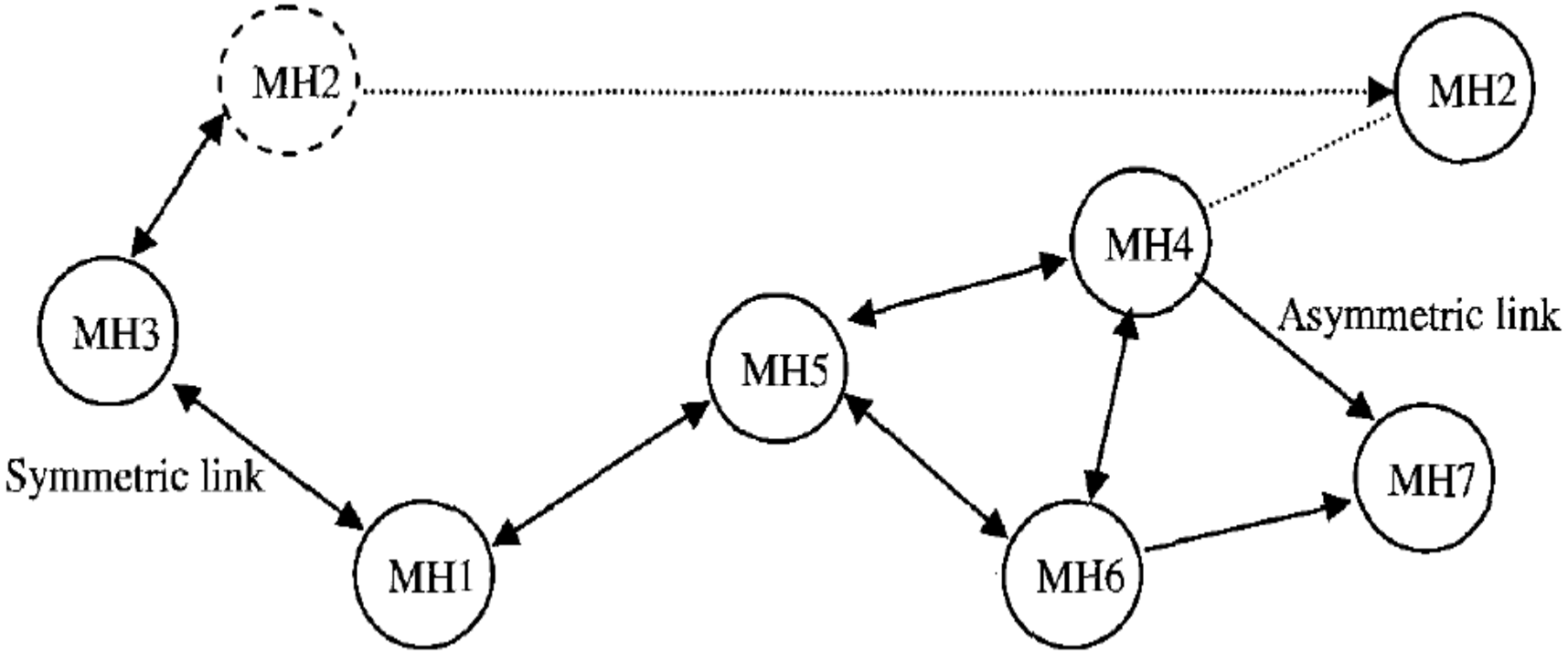
There are many challenges in design, deployment, and performance of ad hoc:

1. Medium access scheme;
2. Routing and multicasting;
3. Transport layer protocol;
4. Quality of service provisioning;
5. Self Organizing
6. Security;
7. Energy management;
8. Addressing and service discovery;
9. Scalability;
10. Deployment considerations.

Note! no good solutions for these challenges.

mode of operation

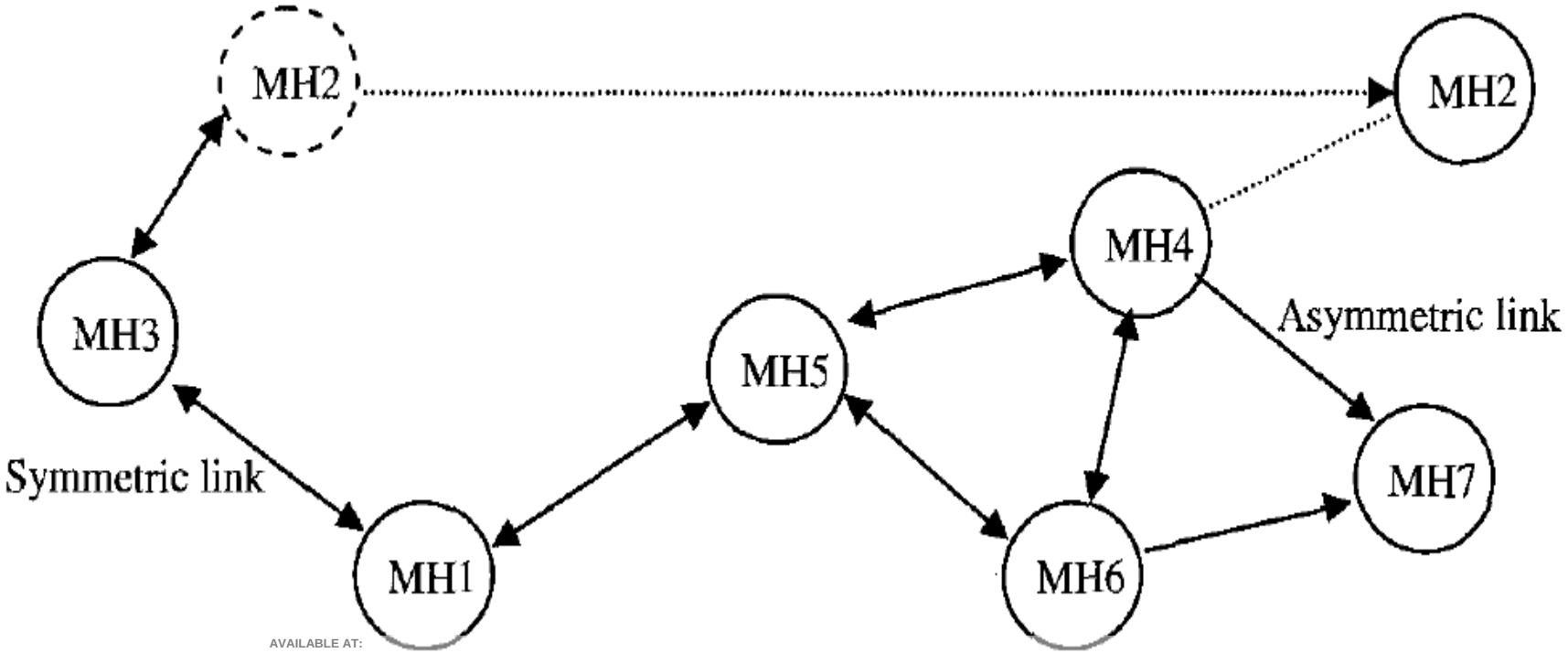
Ad hoc networks are basically peer-to-peer multi-hop mobile wireless networks where information packets are transmitted in a store-and-forward manner from a source to an arbitrary destination, via intermediate nodes as shown in Figure. Mobile Host (MH)



Symmetric and asymmetric are related to radio range: some protocols concentrate on sy……

As the MHs move, the resulting change in network topology must be made known to the other nodes so that outdated topology information can be updated or removed.

For example, as the MH2 in the above Figure changes its point of attachment from MH3 to MH4 other nodes part of the network should use this new route to forward packets to MH2.



Important characteristics of a Mobile Ad Hoc Network (MANET)

- Dynamic Topologies : nodes move randomly with different speeds, network topology changes
- Energy-constrained Operation: nodes also involve in network management, system and applications be designed to save the energy
- Limited Bandwidth: Transmission rate is low
- Security Threats: Mobile wireless networks are generally more prone to physical security threats than fixed-cable nets. Security services be designed carefully

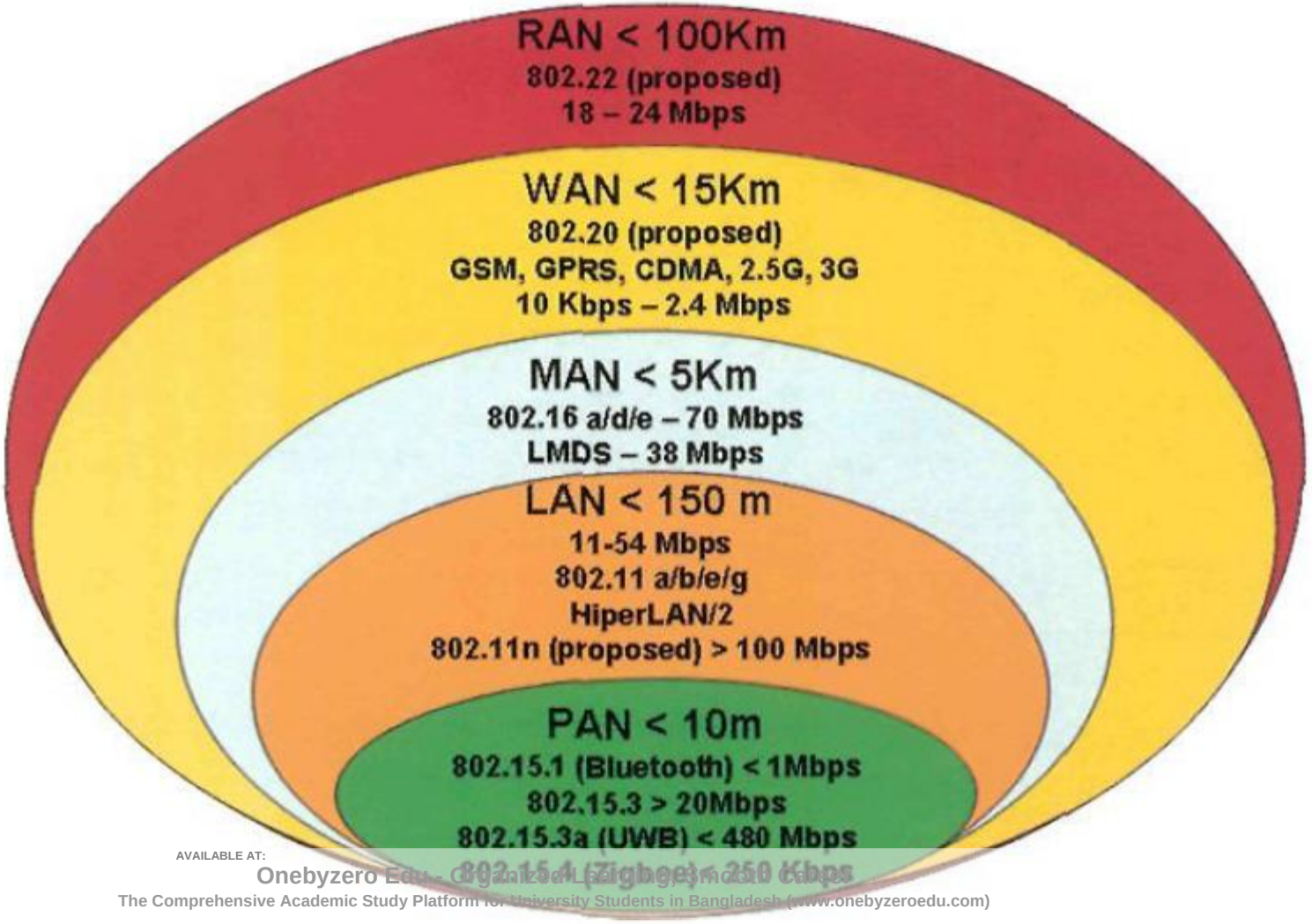
The Communication Puzzle

- There are different types of wireless networks with different transmission speeds and ranges
- Personal Area Network (PAN) personal objects
- Local Area Network(LAN) single building or campus
- Metropolitan Area Networks (MAN) towns and cities
- Wide Area Network (WAN) states, countries, continents
- Regional Area Network (RAN) to provide coverage ranges in the order of tens of kilometers with applications in rural and remote areas

All these are differed by the physical distance that the network spans

LAN, MAN and WAN were originally started as wired network, PANs and RANs, on the other hand, have been introduced with wireless connectivity in mind

- Figure below compares various wireless networks in terms of the popular standards, speeds, communication ranges and applications



- ad hoc networks are mostly within the framework of Wireless LANs and Wireless PANs, a lot of movement is currently undergoing as to integrate ad hoc networks with MANs and WWANs
- With this it would be easy to connect the ad hoc network with the outside world (e.g., Internet)
- While the mobile devices are equipped with dual mode and dual band radio frequencies , heterogeneous networks will become more and more common and the need to integrate them will be of paramount importance

Applications of MANETs

Day-to-day applications like email and file transfer can be easily deployable within an ad hoc network environment

Web Services: can also be implemented with ad hoc networks, where any node in the network can serve as a gateway to the outside world.

Military Applications: Ad Hoc networks were developed by keeping in mind military applications. Infrastructure network is almost impossible to establish or maintain in the battle field in an unknown region. The ad hoc networks having self-organizing capability can be effectively used in these situations.

Crisis Management: In case of crisis management, infrastructure may be destroyed, in such cases ad hoc networks are useful.

Personal Area Networking: managing personal things like printers, cell phones, PDAs, laptops, headsets, and so on. (ad hoc network can be replaced with bluetooth)

Challenges:

- Active research is going on in Adhoc, several aspects have been explored, many problems have been arisen, still some issues to be addressed.
- Major challenges are:

  1.Scalability;

  2.Quality of service;

  3.Client server model shift;

  4.Security;

  5.Interoperation with the Internet;

  6.Energy conservation;

  7.Node cooperation;

  8.Interoperation.

Scalability

- Ad hoc networks suffer, by nature, from the scalability problems in capacity.
- In a non-cooperative network, where omni-directional antennas are being used, the through put per node decreases at a rate 1/(sqrt(N)),where N is the number of nodes.
- That is, in a network with100 nodes, a single device gets, at most, approximately one tenth of the theoretical network data rate. The problem fixed with bi directional antennas
- As the network size increases the problems like Route acquisition, service location and encryption key exchanges need to be solved.

Quality of Service

- There are many applications for transfer of Voice, live video, and file transfer.
- QoS parameters such as delay, jitter, bandwidth, Packet loss probability, and so on need to be addressed carefully.
- Issues of QoS robustness, QoS routing policies, algorithms and protocols with multiple, including preemptive, priorities remain to be addressed.

Client-Server Model Shift

- Address allocation, name resolution, authentication and the

Service location are just examples of the very basic services which are done by the servers but in ad hoc some nodes do all these and their location in the network is unknown and possibly even changing over time.

- The issue of shift from the traditional client-sever model remains to be appropriately addressed

Security

- Lack of any centralized network management or certification

authority makes these dynamically changing wireless structures leads security threats like infiltration, eavesdropping, interference, and so on.

- Security is indeed one of the most difficult problems to be solved, but it has received only modest attention so far

Interoperation with the Internet

- It seems very likely that the most common applications of adhoc networks require some Internet connection.

Energy Conservation

- There are two primary research topics: maximization of life time of a single node and maximization of the life time of the whole network.
- These goals can be achieved either by developing better batteries, or by making the network terminals‘ operation more energy efficient.
- The first approach is likely to give a 40% increase in battery life, remaining 60% can be achieved though the design of energy efficient protocols design

Wireless Sensor Networks

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- WSN Node
- Architecture of sensor node
- WSN vs MANET
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Introduction

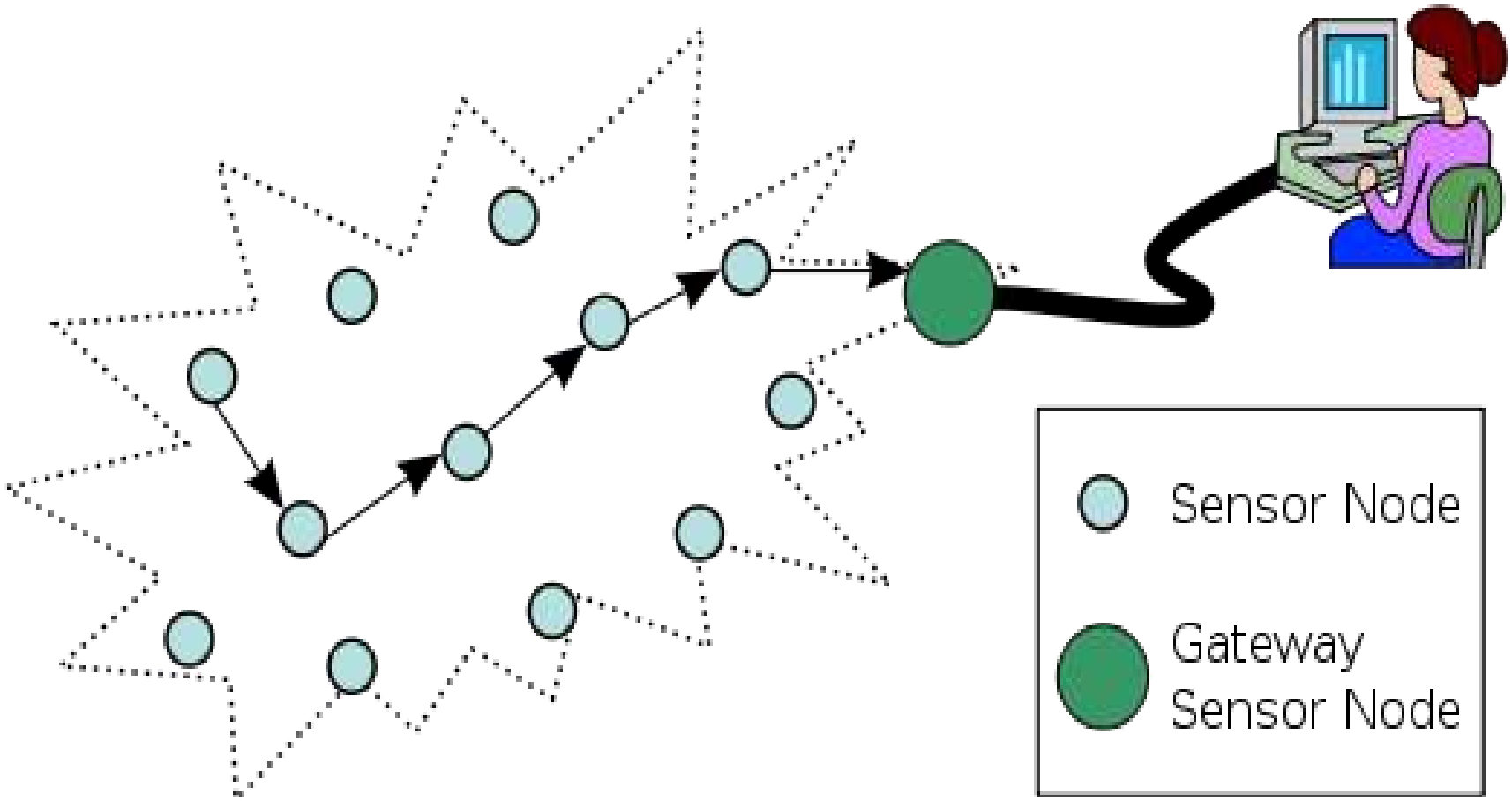
- A wireless sensor network (WSN) is a wireless network consisting of spatially distributed autonomous devices using sensors to cooperatively monitor physical or environmental conditions, such as temperature, sound, vibration, pressure, motion or pollutants, at different locations.

- A collection of sensing devices that can communicate wirelessly.

Wireless Sensor Networks(WSN)

- Even though wireless sensors has limited resources in memory, computation power, bandwidth, and energy.
- With small physical size. It Can be embedded in the physical environment.
- Self-organizing multi-hop ad-doc networks

Wireless Sensor Network Architecture



Architecture for a WSN

Special addressing requirement

- Local unique addresses
- Data-centric
- *Example: Each node has an unique number.*

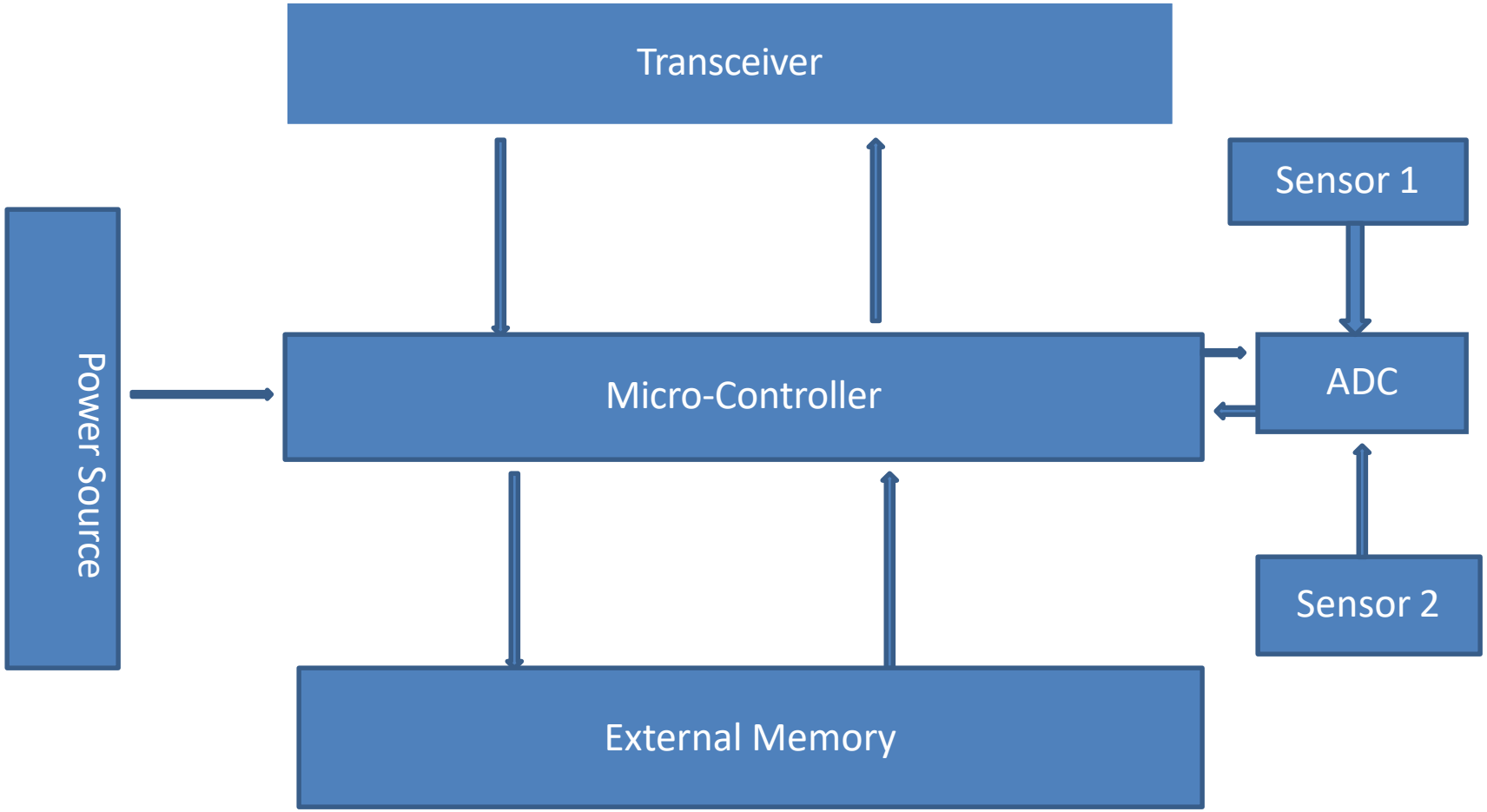
Attribute-based naming architecture

- Data is named by one or more attributes.
- *Example: Each node is distinguished by an attribute – GPS sensors are practical for this.*

Wireless Sensor Node

- sensor
  - A transducer
  - converts physical phenomenon e.g. heat, light, motion, vibration, and sound into electrical signals
- sensor node
  - basic unit in sensor network
  - contains on-board sensors, processor, memory, transceiver, and power supply
- sensor network
  - consists of a large number of sensor nodes
  - nodes deployed either inside or very close to the sensed phenomenon

Architecture of Sensor Node



Data Aggregation in WSNs

- Solves implosion and overlap problem
- Energy efficient

Wireless Sensor Network(WSN) vs. Mobile Ad Hoc Network (MANET)

	WSN	**MANET**
Similarity	Wireless	Multi-hop networking
Security	Symmetric Key Cryptography	Public Key Cryptography
Routing	Support specialized traffic pattern. Cannot afford to have too many node states and packet overhead	Support any node pairs Some source routing and distance vector protocol incur heavy control traffic
Resource	Tighter resources (power, processor speed, bandwidth)	Not as tight.

Characteristics

- Power consumption constraints for nodes using batteries or energy harvesting
- Ability to cope with node failures (resilience)
- Mobility of nodes
- Heterogeneity of nodes
- Scalability to large scale of deployment
- Ability to withstand harsh environmental conditions
- Ease of use
- Cross-layer design

Factors Influencing WSN Design

- Fault tolerance
- Scalability
- Production costs
- Hardware constraints
- Sensor network topology
- Environment
- Transmission media
- Power Consumption
  - Sensing
  - Communication
  - Data processing

Applications

- Military Applications
- Environmental Applications
- Health Applications
- Home and Office Applications
- Automotive Applications
- Other Commercial Applications

Advantages

- It avoids a lot of wiring .
- It can accommodate new devices at any time .
- It's flexible to go through physical partitions .
- It can be accessed through a centralized monitor

Disadvantages

- Lower speed compared to wired network.
- Less secure because hacker's laptop can act as Access Point. If you connected to their laptop, they'll read all your information (username, password.. etc).
- More complex to configure than wired network.
- Gets distracted by various elements like Blue-tooth .
- Still Costly at large.
- It does not make sensing quantities in buildings easier.
- It does not reduce costs for installation of sensors.
- It does not allow us to do more than can be done with a wired system

Design Challenges

- **Heterogeneity**
  - The devices deployed may be of various types and need to collaborate with each other.
- **Distributed Processing**
  - The algorithms need to be centralized as the processing is carried out on different nodes.
- **Low Bandwidth Communication**
  - The data should be transferred efficiently between sensors

Continued..

- **Large Scale Coordination**
  - The sensors need to coordinate with each other to produce required results.
- **Utilization of Sensors**
  - The sensors should be utilized in a ways that produce the maximum performance and use less energy.
- **Real Time Computation**
  - The computation should be done quickly as new data is always being generated.

Operational Challenges of Wireless Sensor Networks

- Energy Efficiency
- Limited storage and computation
- Low bandwidth and high error rates
- Errors are common
  - Wireless communication
  - Noisy measurements
  - Node failure are expected
- Scalability to a large number of sensor nodes
- Survivability in harsh environments
- Experiments are time- and space-intensive

Future of WSN

Smart Home / Smart Office

- Sensors controlling appliances and electrical devices in the house.
- Better lighting and heating in office buildings.
- The Pentagon building has used sensors extensively.

Conclusion

- WSNs possible today due to technological advancement in various domains
- Envisioned to become an essential part of our lives
- Design Constraints need to be satisfied for realization of sensor networks
- Tremendous research efforts being made in different layers of WSNs protocol stack

References

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Thank you!