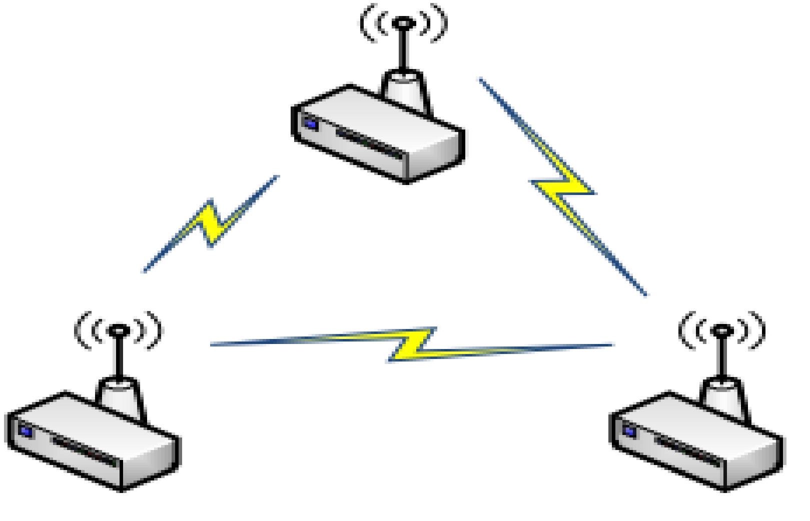
Topologies

The four WSN data network topologies

- Peer-Peer
- Star
- Tree
- Mesh

Peer-Peer

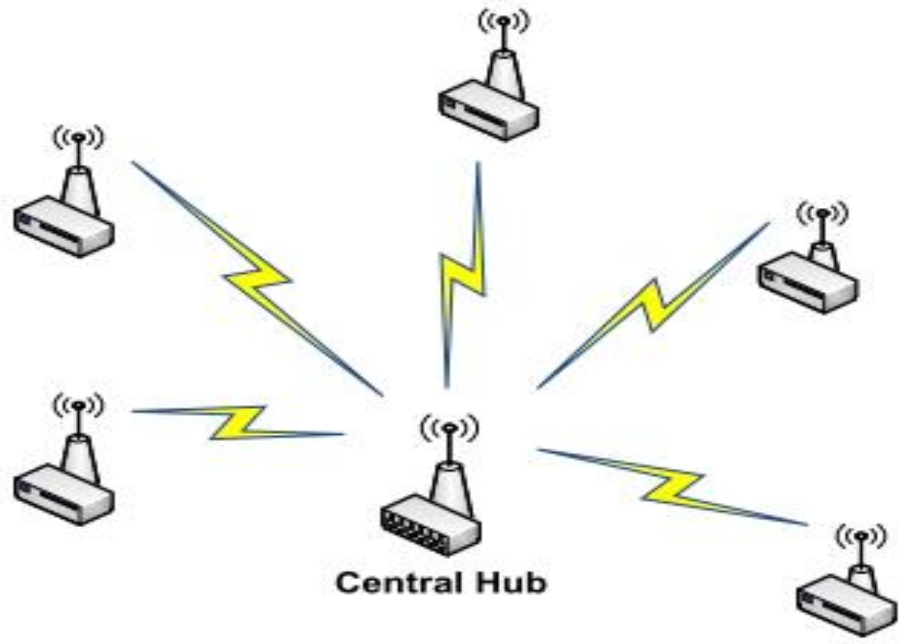
- Peer-to-Peer networks allow each node to communicate directly with another node without needing to go through a centralized communications hub.
- In the peer-to-peer topology sensors (devices) may communicate directly



Star

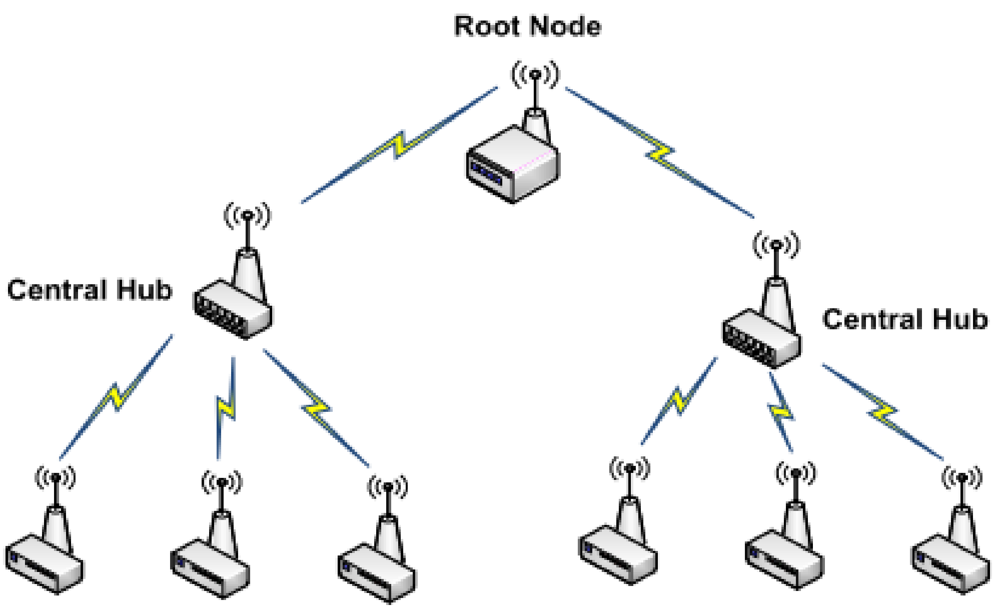
- Star networks are connected to a centralized communications hub.
- Each node cannot communicate directly with one another; all communications must be routed through the centralized hub in the star-shape topology they must communicate through a coordinator
- A classical star topology of WSANs was studied in Korber et al. (2007).
- In the star topology, the BS serves as a network controller and as a gateway to upper layers.

Star



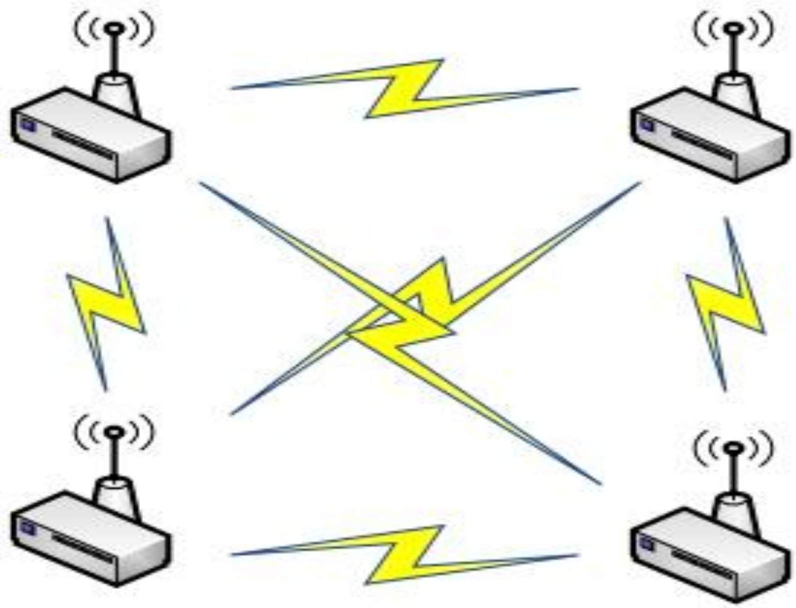
Tree

- Tree networks use a central hub called a Root node as the main communications router.
- One level down from the Root node in the hierarchy is a Central hub. This lower level then forms a Star network.
- The Tree network can be considered a hybrid of both the Star and Peer to Peer networking topologies.



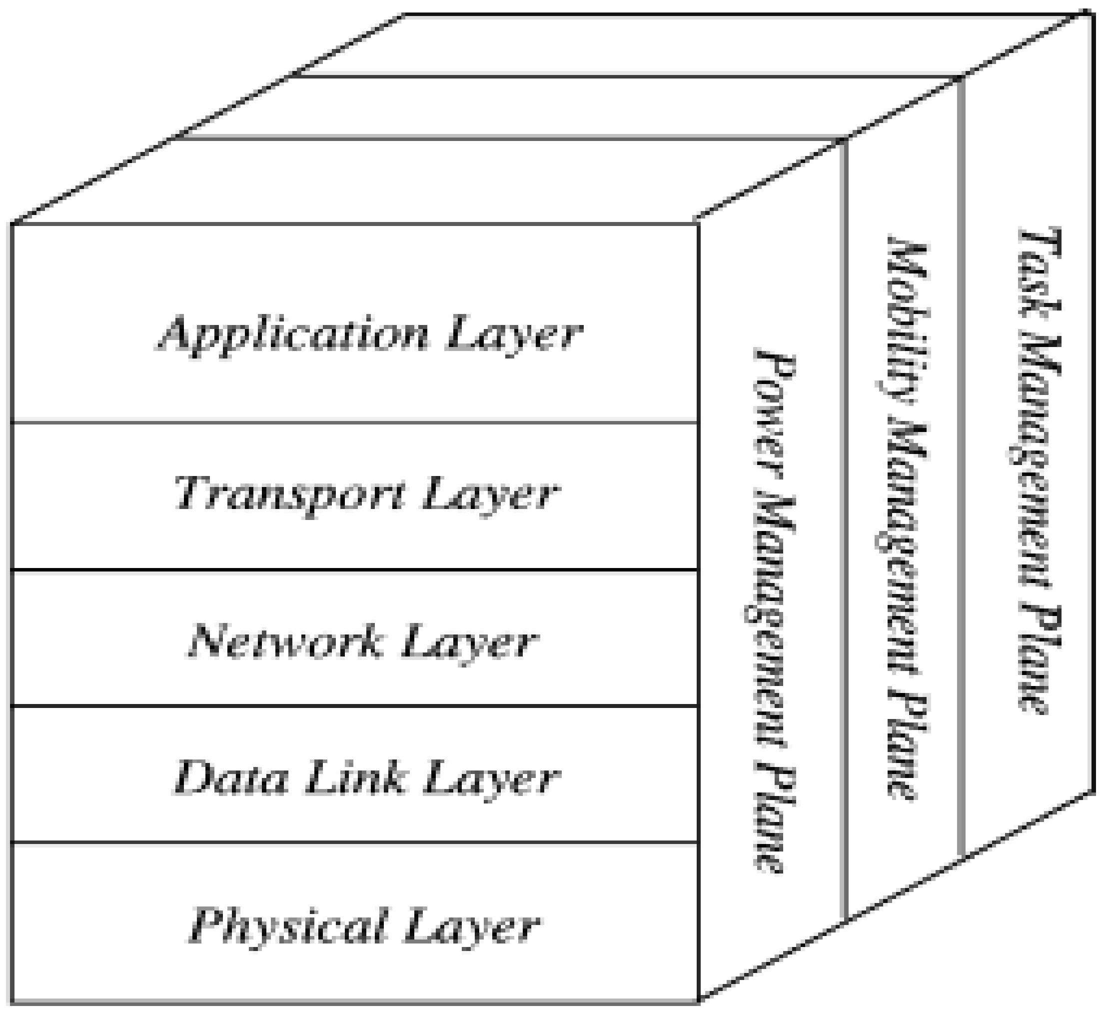
Mesh

- Mesh networks allow data to “hop” from node to node, this allows the network to be self-healing.
- Each node is then able to communicate with each other as data is routed from node to node until it reaches the desired location.
- This type of network is one of the most complex and can cost a significant amount of money to deploy properly.



- After the placement, the connectivity of the topology is checked.
- In WSAN if the node fails the topology will be reorganized into a new topology
- The desired network topology is achieved once the generated topology passes the connectivity test (usually Dijkstra’s shortest path algorithm is used).

The Sensor N/W Protocol stack



The Power Management Plane

- The power management plane manages how a sensor node uses its power.
- The sensor node may turn off its receiver after receiving a message from one of its neighbors. This is to avoid getting duplicated messages.
- When the power level of the sensor node is low, the sensor node broadcasts to its neighbors that it is low in power and cannot participate in routing messages. The remaining power is reserved for sensing.

The Mobility Management Plane

- The mobility management plane detects and registers the movement of sensor nodes, so a route back to the user is always maintained, and the sensor nodes can keep track of who are their neighbor sensor nodes.

- By knowing who are the neighbor sensor nodes, the sensor nodes can balance their power and task usag

The Task Management Plane

- The task management plane balances and schedules the sensing tasks given to a specific region.
- Not all sensor nodes in that region
- are required to perform the sensing task at the same time. As a result, some sensor nodes perform the task more than the others depending on their power level.
-

Need of Management Planes

- These management planes are needed, so that sensor nodes can work together in a power efficient way, route data in a mobile sensor network, and share resources between sensor nodes.

Problems in Physical Layer

- required to process signals
- deal with the hardware failure of sensor nodes,
- manage limited bandwidth and limited power,
- Control sensing range and transmission range
- select antennas and operating channels.

Problems in MAC Layer

- Aims at energy-efficient and collision-free communications.

Problems in Transport Layer

- Data gathering and data aggregation is scheduled in order to reduce traffic, increase reliability, and provide QoS control. Most of these problems are well-studied in WSNs and ad hoc networks.

Problems in Network Layer

- Topology control,
- Routing,
- Coordination.

Need of Topology Control

- A well-organized network topology can not only prolong the lifetime of a network, but also enhance data communications

Topology Control Problems

- Neighbor discovery problems
- Network organization problems.

Neighbor discovery problems

- problems in detecting and discovering neighbors which are located within the transmission range.
- In the network organization problems, each node chooses its neighbors and constructs local topology by either adjusting its transmission power or setting its status,such as sleep and active modes.

- The most important topology control, especially for power-critical sensor networks, is to place as many possible sensor (and similarly actor)
- All nodes that are not essential for communication or area coverage can be placed in sleep mode for prolonged periods

Energy efficiency at the MAC layer, which are also based on topology control.

- S-MAC (Ye et al., 2004) divides nodes into clusters based on fixed common sleep schedules to reduce control overhead and enable traffic-adaptive wake-up.
- T-MAC (Dam and Langendoen, 2003) extends S-MAC by adjusting the length of the waking time of the nodes based on the communication of neighboring nodes.
- B-MAC (Polastre et al., 2004) employs an adaptive preamble sampling scheme to reduce the duty cycle and minimize idle listening

Topology Control Scheme

- selecting certain nodes from the network to create a backbone
- backbone structures are used to improve the efficiency of data communication protocols
- routing or broadcasting remains successful if intermediate nodes are selected only from connected backbones since each nonbackbone node has a neighbor from the backbone

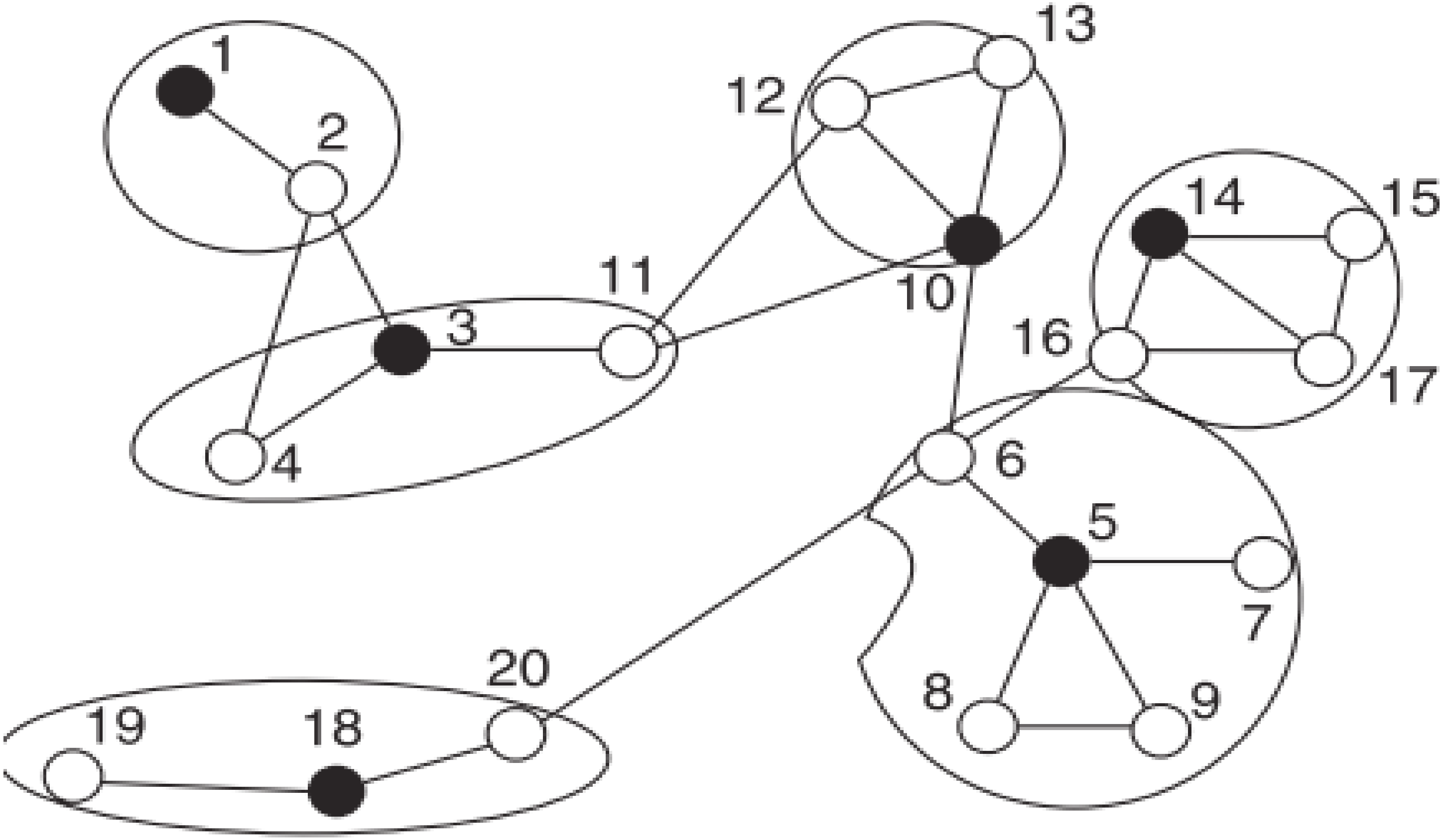
How to create backbone

- Clustering
- Connected dominating sets (CDSs)

Clustering

- clustering process divides the nodes of a network into several clusters.
- In each cluster, there is a clusterhead, which is responsible for the coordination and data communication between nodes in the cluster.
- The selection of clusterheads is done via global nomination or local election, according to a certain protocol.
- Communications within a cluster could be one hop or multihop.
- The backbonecould contain only clusterheads or may include some gateway nodes to enable connectivity.

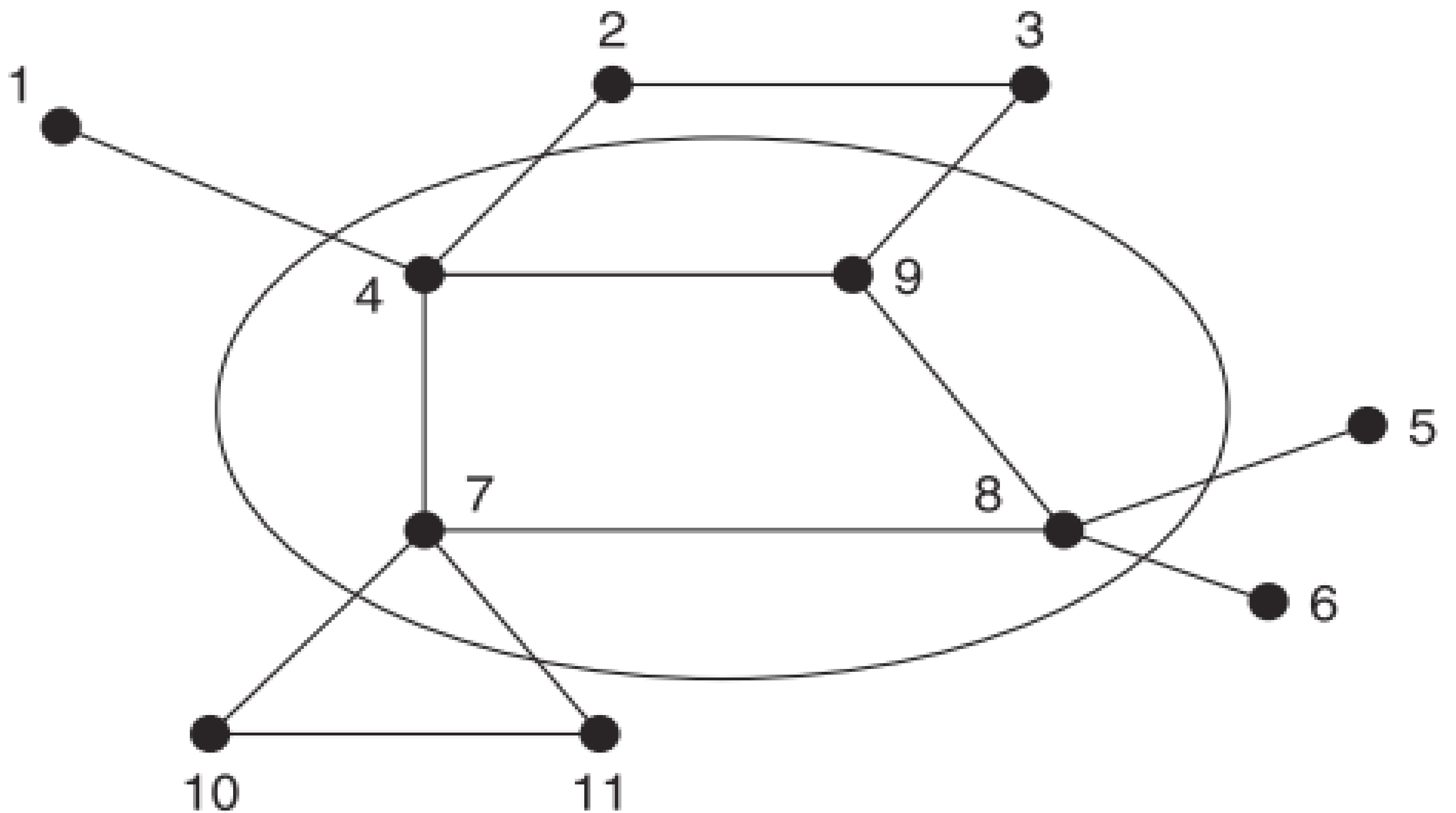
Clustering



Connected Dominating Sets (CDs)

- A subset of the vertices of a graph is called a dominating set if every vertex in the graph is either in the subset or is adjacent to at least one vertex in the subset.
- A CDS requires also connectivity among the backbone nodes.

CDS



CDs

- In the example of Figure

  subsets { 1, 2, 3, 5, 6, 10 } and
  { 4, 7, 8, 9 } are dominating sets.

The subset { 4, 7, 8, 9 } is also CDS while the former one is not.