4- Network

Internet of Things

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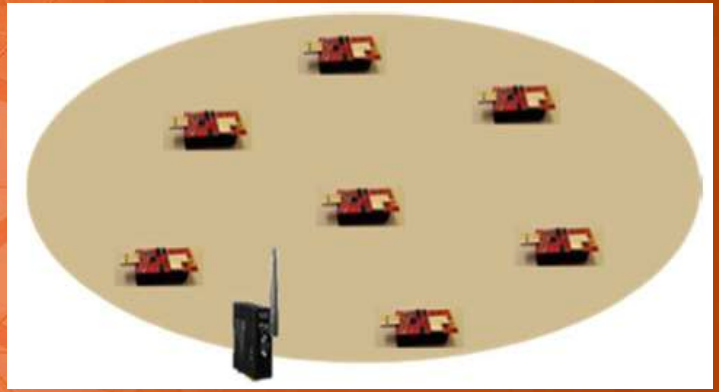
Overview

- Network Module
- Routing Technology
- Performance Issues

Network Module



RF-Based IoT Applications

Communication module only provides data link solution
i.e. transmitting a packet between nodes within the radio range

Network module is needed to provide a solution for end-to-end packet delivery

- Since source/destination pair may not be within each other radio range, intermediate nodes are needed to forward packet.
- It is a distributed system. All nodes need to perform networking related tasks.
- It is often software implementation.

RF-Based IoT Applications

RF-based IoT applications: Multi-hop Wireless Network. Some examples:

- Wireless Sensor Networks (WSNs)
- Mobile Wireless Ad hoc Networks (MANETs) – Wireless Mesh Networks (WMNs)
- Vehicular Ad Hoc Networks (VANETs)
- and others...

Main concern: Reliability & Performance

Network Module: Roles

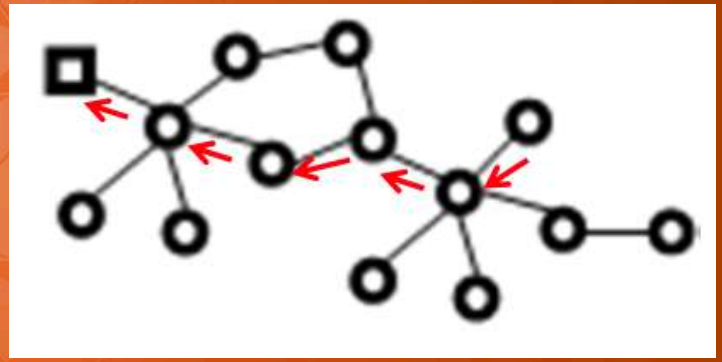
Management:

- Packet: Adapting the packet sizes and formats
- Address: Adapting and/or resolving addresses
- Device: Joining/leaving of nodes
- Service: Providing adds-on services such as security

Operational:

- Route discovery & maintenance
- Packet forwarding

Routing Technologies



Common Routing Technologies

Flooding

- When receiving a packet, each node rebroadcasts the packet
- No memory is kept in a node
- Very wasteful in bandwidth usage

Source Routing

- A source node partially or completely specifies the route that a packet should be forwarded
- Source node is responsible for finding the route to the destination
- Implementation: DSR

Common Routing Techniques

Distance Vector

- Exchange distance vectors only with neighbours to establish routing tables
- Less traffic for table maintenance makes it suitable for wireless networks
- Implementation: RIP, AODV, etc.

Link State

- Flood link information in the network and use Dijkstra's algorithm to compute routing tables
- Popular solution in wired network. Not adequate for wireless, as it requires network-wide flooding
- Implementation: OSPF, OLSR, etc.

Common Routing Techniques

Path Vector

- Based on distance vector, path information is used instead of distance
- Permit implementation of some policy to take control of the route
- Used in inter-domain routing
- Implementation: BGP

Route Establishment & Maintenance

Proactive (table-driven):

- Nodes maintain a table describing how a packet should be forwarded to destinations
- It is more suitable for networks with static topology

Reactive (on-demand):

- Upon a request, nodes flood the network to find the destination
- It is more suitable for networks with changing topology

Mixed:

- Hybrid: Operate both proactive and reactive routing
- Hierarchical: Separate nodes into different levels and use different routing techniques in different levels

Routing in IoT

Ad hoc On-demand Distance Vector (AODV)

- Specified in RFC 3561
- Implemented in ZigBee

IPv6 Routing Protocol for Low-Power and Lossy Networks (RPL)

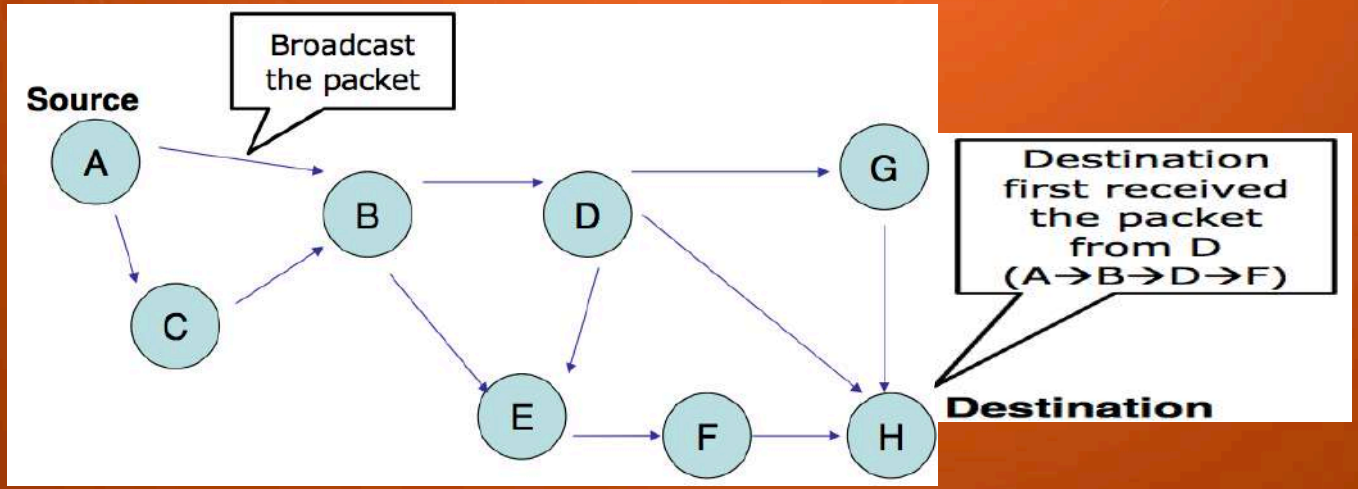
- Specified in RFC 6550
- Implemented in Contiki OS, Tiny OS

NOTE: We'll also review Flooding & Source Routing

Flooding

When receiving a packet

- If it is not seen before, broadcast the packet
- Else discard the packet



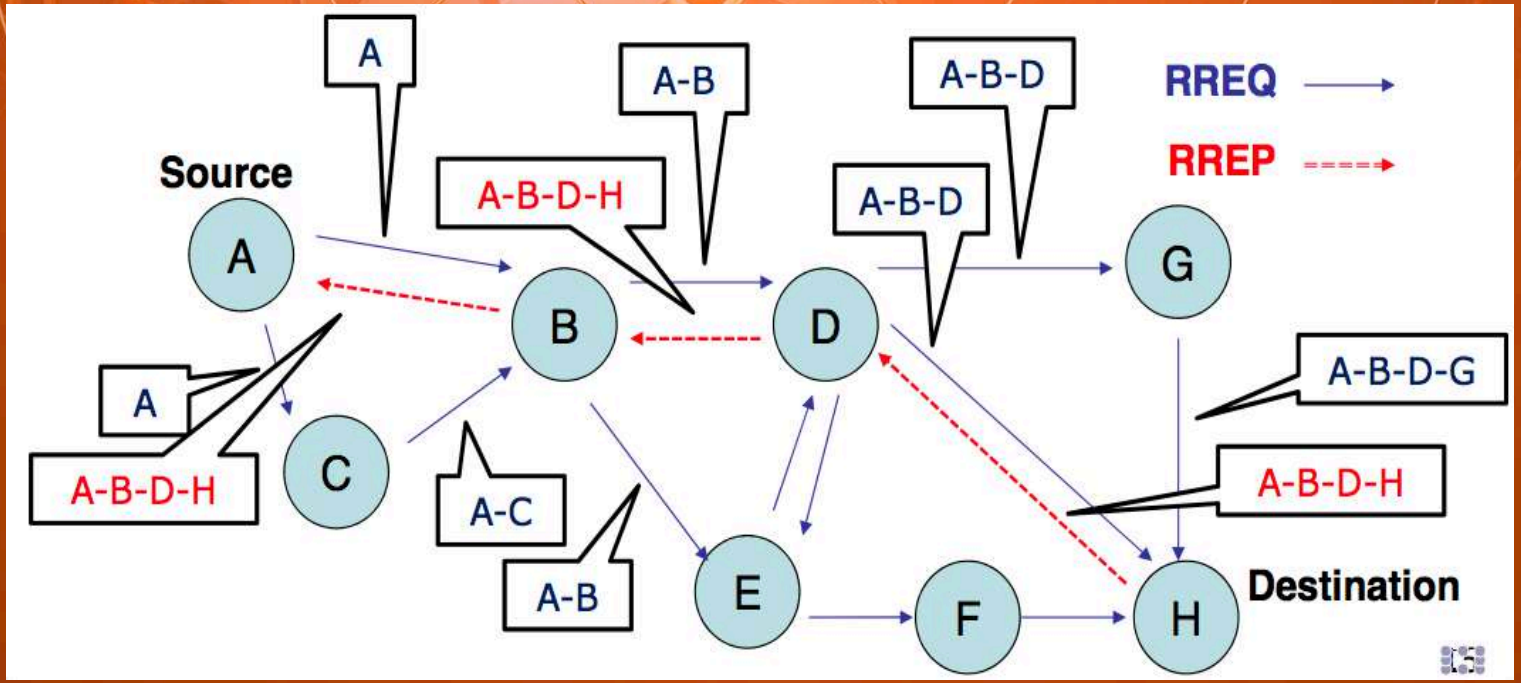
Source Routing

In source routing, the source takes control of the forwarding

Basic idea:

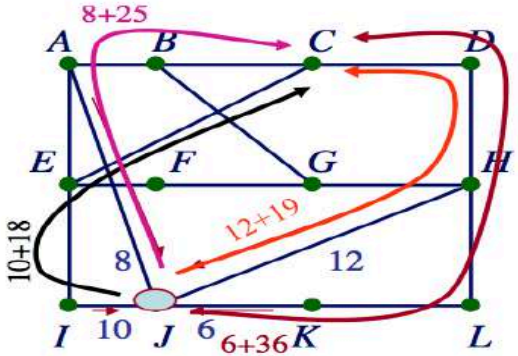
- The SOURCE broadcasts a REQUEST
- Each node include the path information in the REQUEST
- When the REQUEST reaches the DESTINATION, the DESTINATION unicasts a REPLY with the path info
- When the REPLY reaches the SOURCE, it may transmit data packet with the received path info included in the header
- Each intermediate node uses the path info in the header to forward the data packets
- Each node maintains route cache to improve route discovery performance

Source Routing



Distance Vector

Node *J* has been switched on



The distance vector published by *A*, *I*, *H*, *K* to *J*:

	A	B	C	D	E	F	G	H	I	J	K	L
A	0	12	25	40	14	23	18	17	21	8	24	29
I	24	36	18	27	7	20	31	20	0	10	22	33
H	20	31	19	8	30	19	6	0	14	12	22	9
K	21	28	36	24	22	40	31	19	22	6	0	9

J's new distance vector and routing table:

	A	B	C	D	E	F	G	H	I	J	K	L
J	8	20	28	20	17	30	18	12	10	0	6	15
via	A	A	I	H	I	I	H	H	I	---	K	K

(source, distance, next hop)
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