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Routing Algorithms for Wireless Sensor Networks

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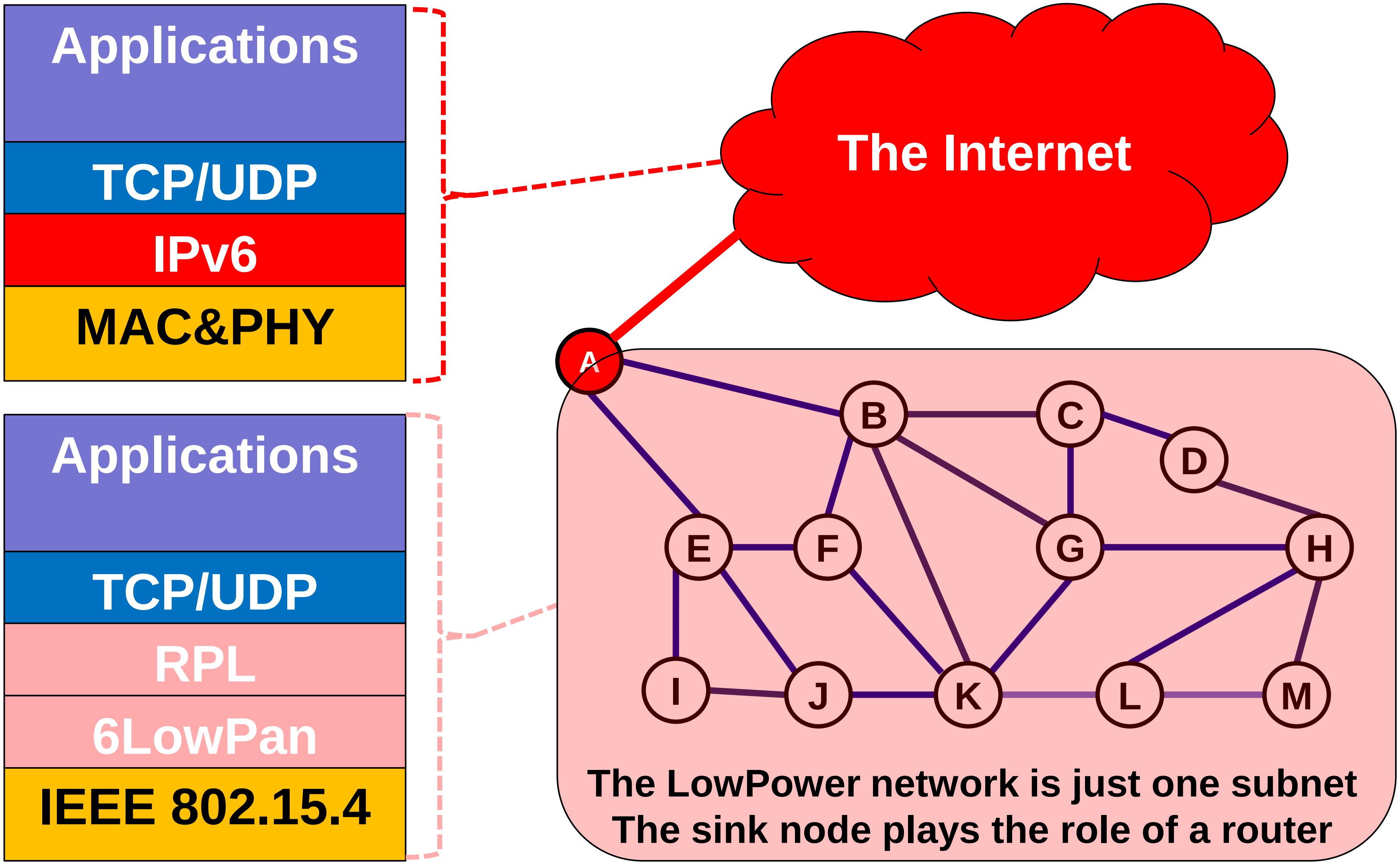
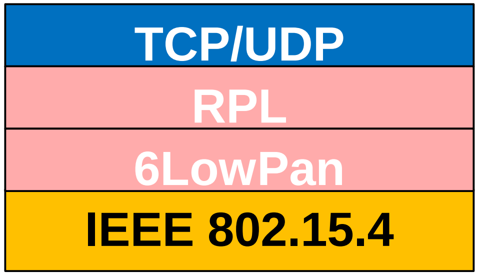
- RPL: IPv6 Routing protocol for low power and lossy networks.

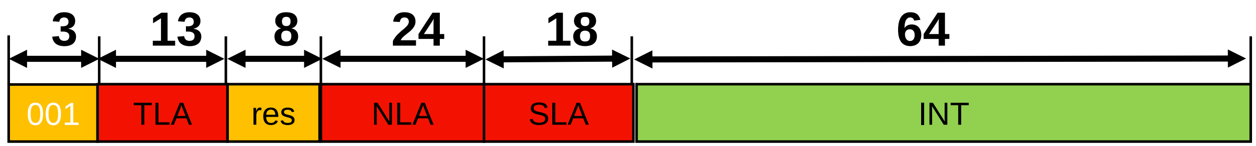
IPv6 on Low Power and Lossy Networks?



6LowPan – Why ?



IPv6 address :



- **Frame length :**
  - **IPv6: <= 1280 bytes; IEEE 802.15.4: <= 81 bytes.**

  Frame fragmentation & defragmentation
- **Header length :**
  - **IPv6 header >= 40 bytes; TCP header = 20 bytes, …**
  - **No version field, no flow label,**
  - **One subnet : 64 instead 128 bit addresses,**

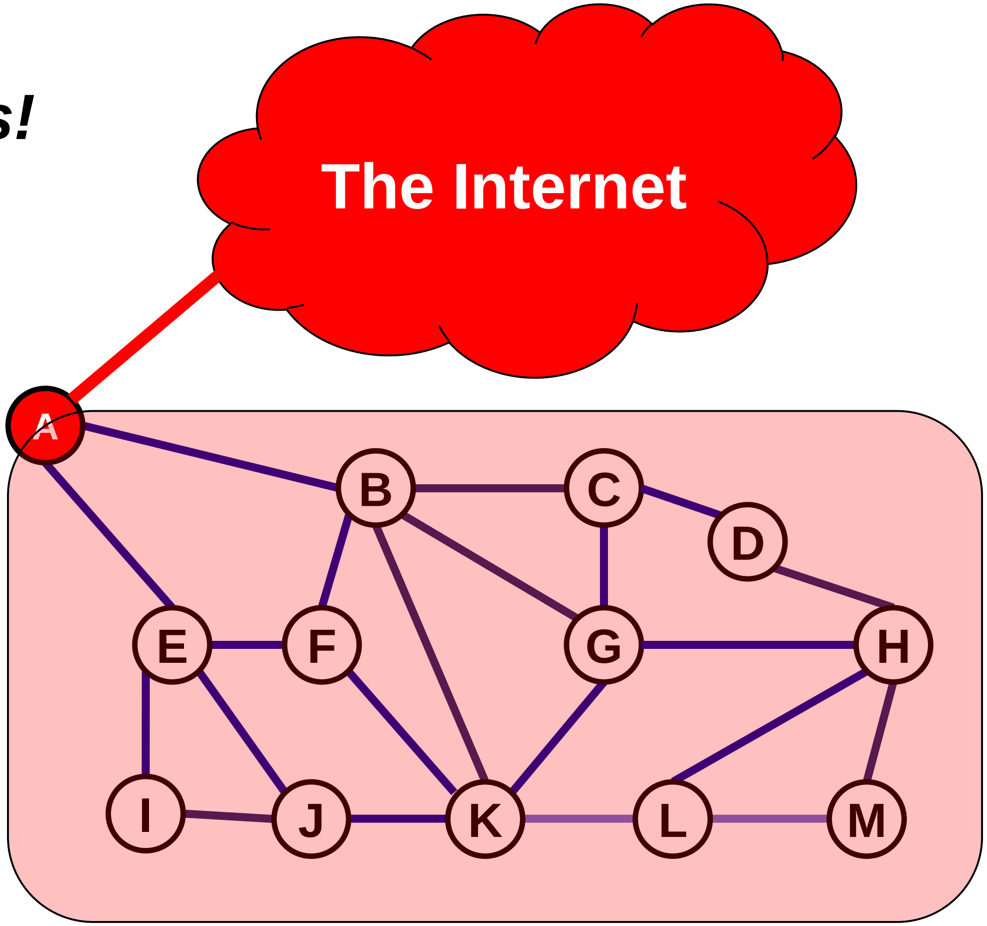
  Header compression
- **Connectivity inside the subnet :**
  - **Single broadcast domain vs. multi-hop connectivity**

  Route-over architecture

6LowPan – Why ?

IPv6 : One subnet = one broadcast domain

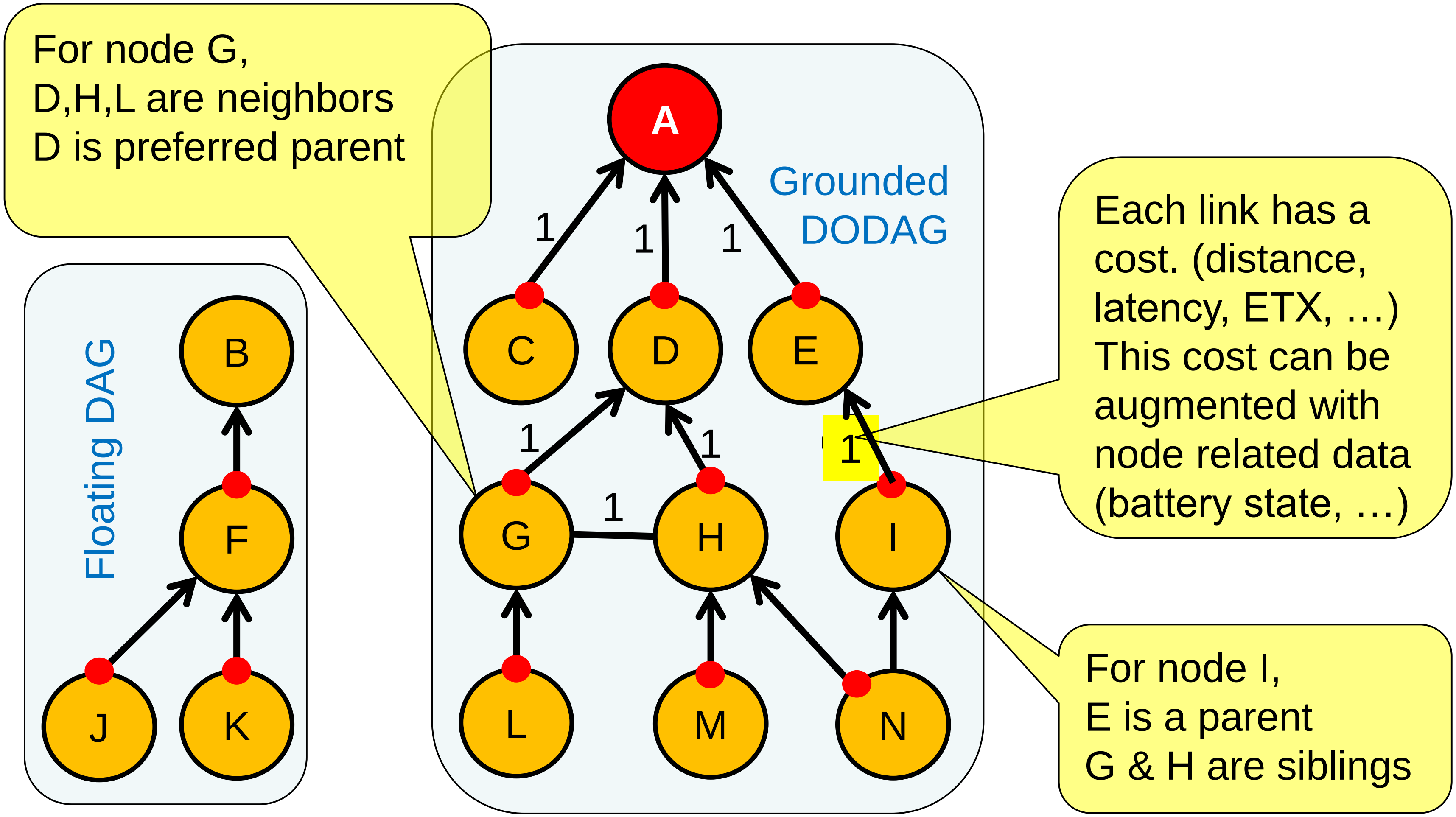
This is not true in LowPans!
Solutions :
- ~~***Link level routing***~~
- ***Routing in the subnet !***
  "Route over"
  uses simplified versions of IPv6 ND protocols.



Routing Protocol for Low Power and Lossy Networks

- RPL origin: “The Internet of things”.
  - IETF working group for IPv6 routing.
  - None of the existing protocols is adequate!
  - New design combining interesting ideas of all.
- RPL Basic Mechanisms
  - Routing based upon one or more Destination Oriented Directed Acyclic Graphs (DODAGs)
    - Optimal routes between sink and all other nodes for both the collect and distribute data traffics.
    - Redundant equivalent routes are kept for reliability in case of link or node failure.
  - Multiple DODAGs if different optimisation criteria.

RPL: the DODAG



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The ETX cost function

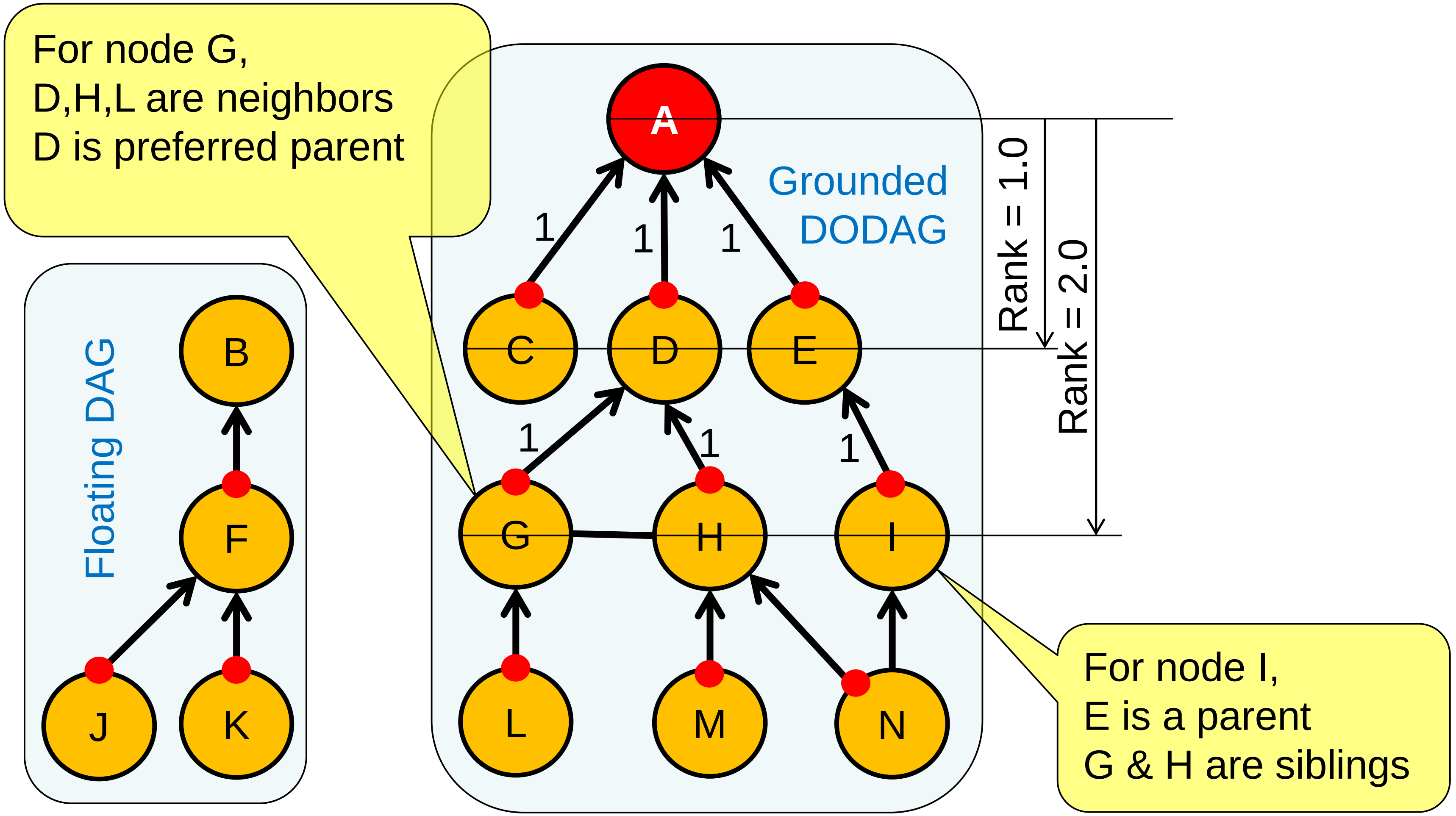
ETX = Estimated number of transmissions from x to y.
= Number of times a frame needs to be transmitted over a link before being acknowledged.
= $(d_{xy} \times d_{yx})^{-1}$ d_{xy} = success rate from x to y.

Each node broadcasts precisely once per second a short message, each receiver counts during 10 seconds the number of broadcasts it receives from each neighbor.

d_{xy} = (number of frames received from x by y) / 10

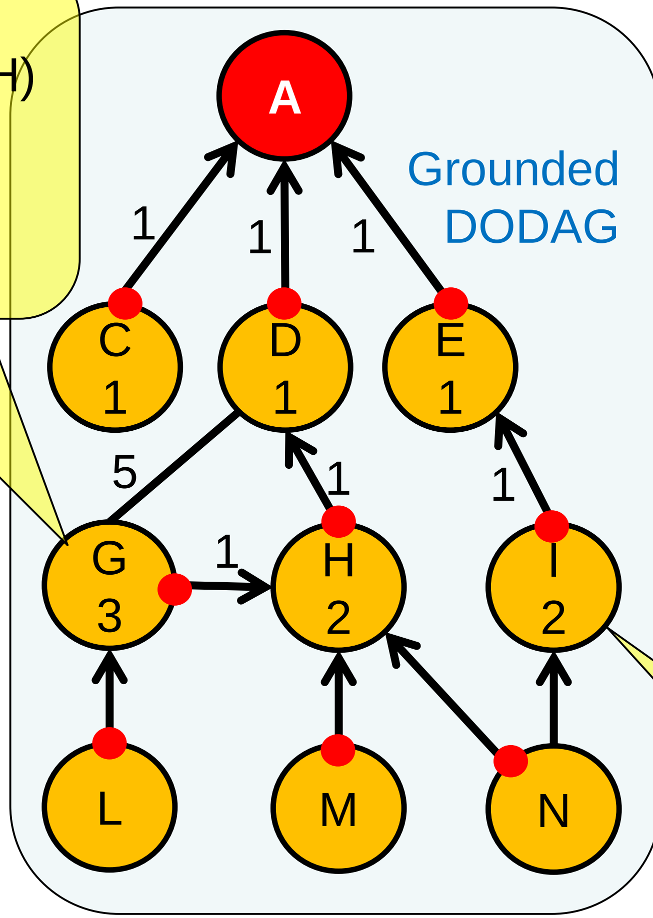
What about RDC ?

RPL: the RANK of nodes in a DODAG



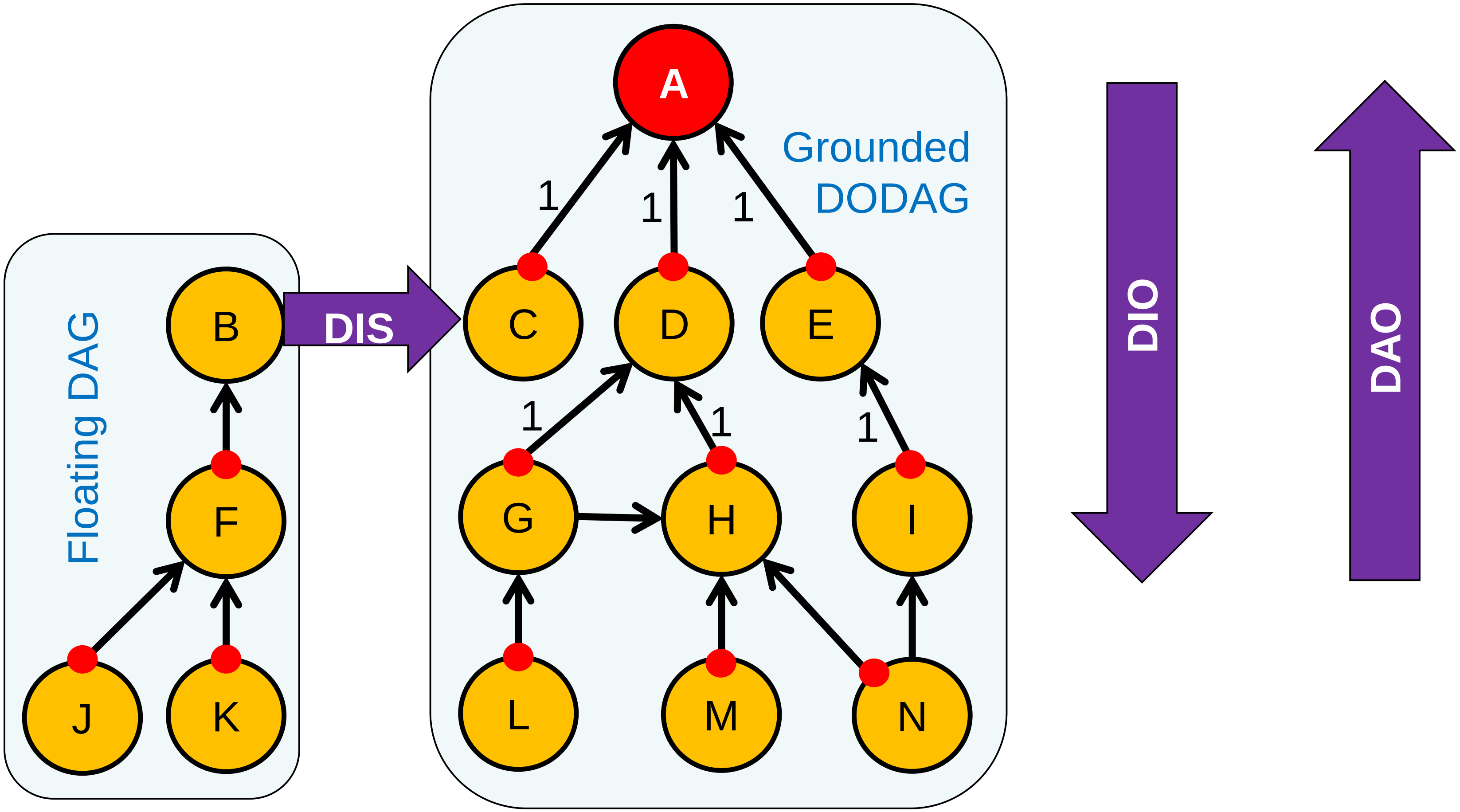
RPL: the RANK of nodes in a DODAG

For node G,
If route via a sibling (H) is “better” , then it should increase its rank.



For node I,
E is a parent
G & H are siblings

RPL: Messages for routing



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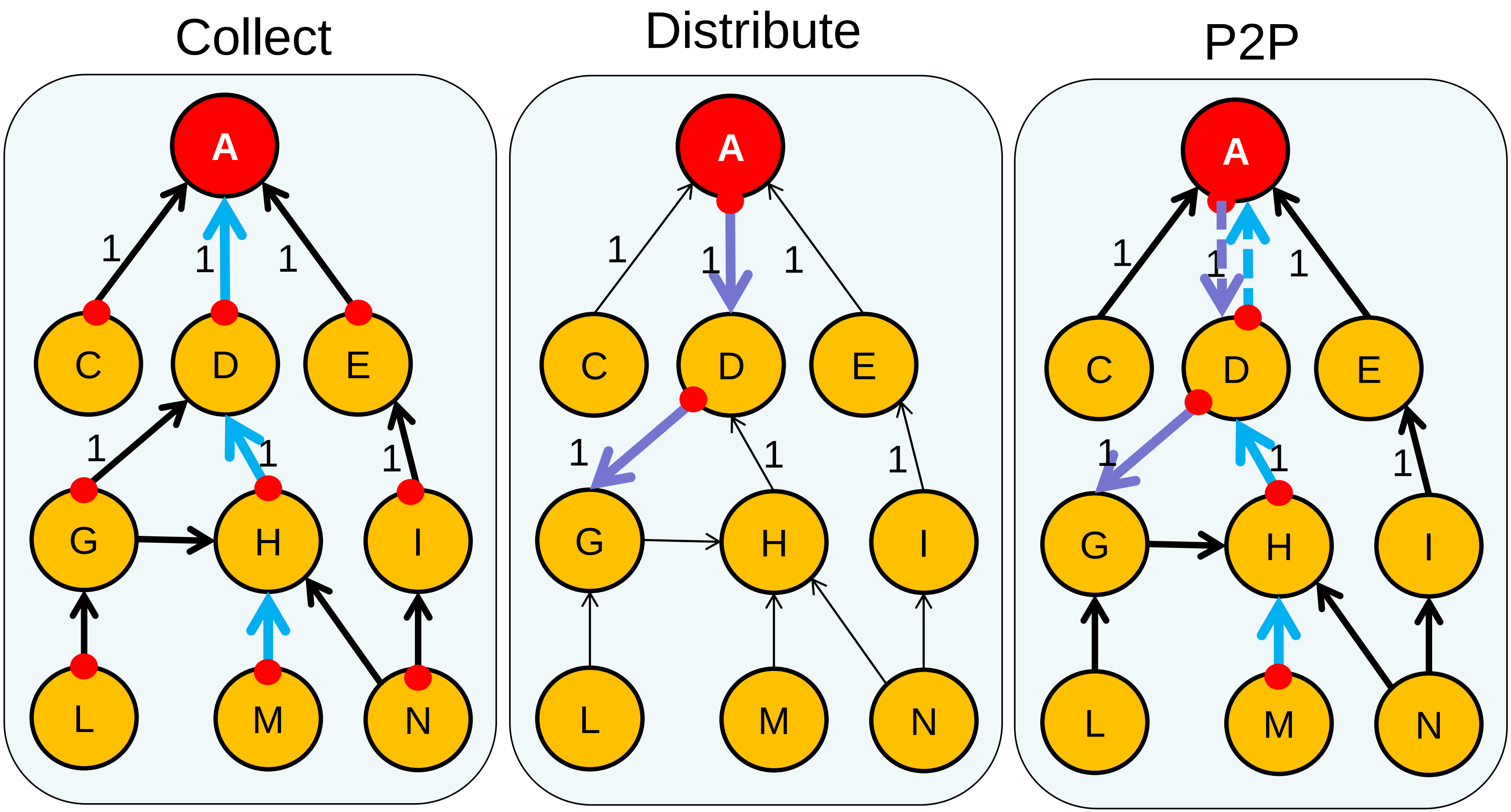
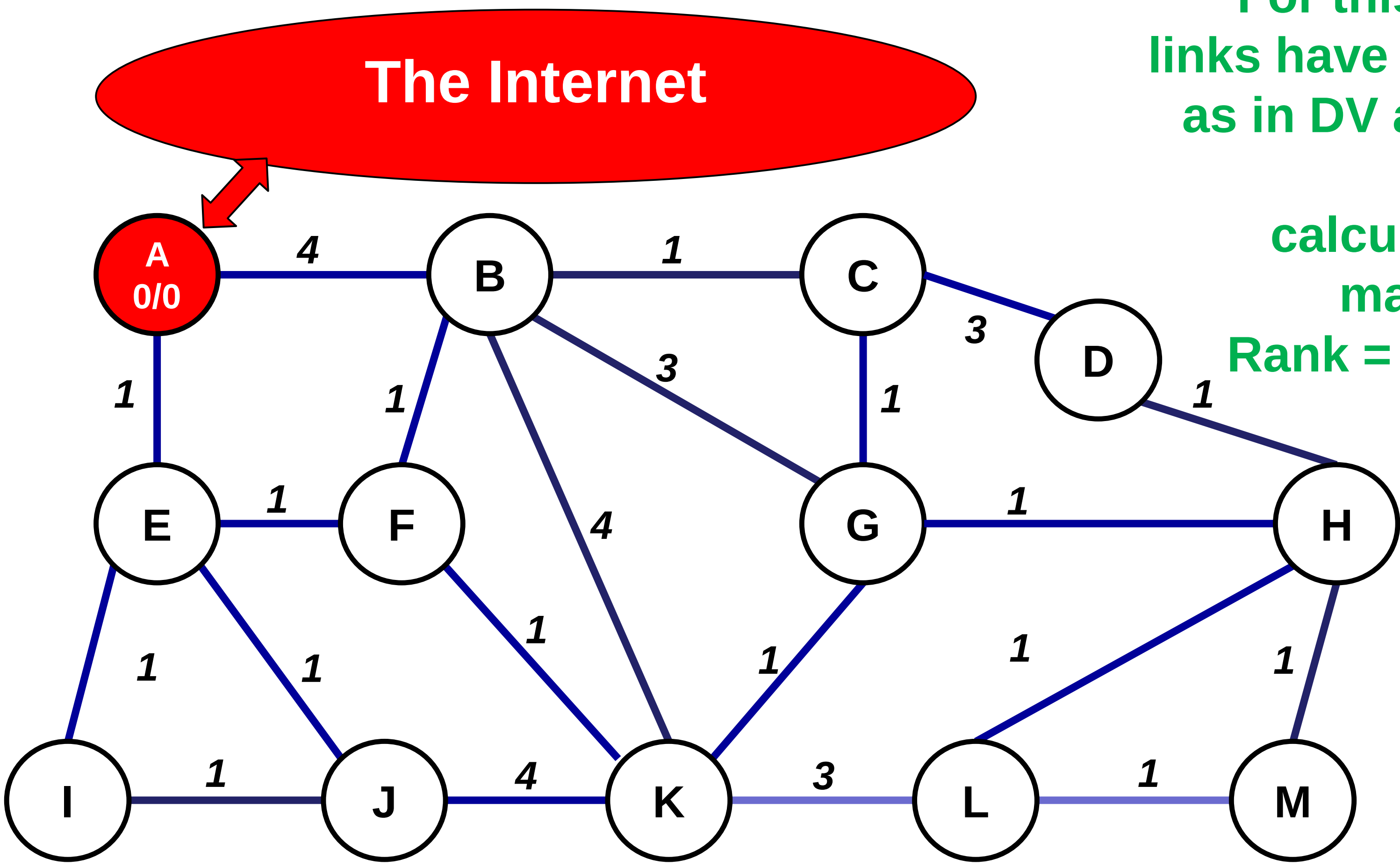
RPL: Collect, Distribute and P2P routing



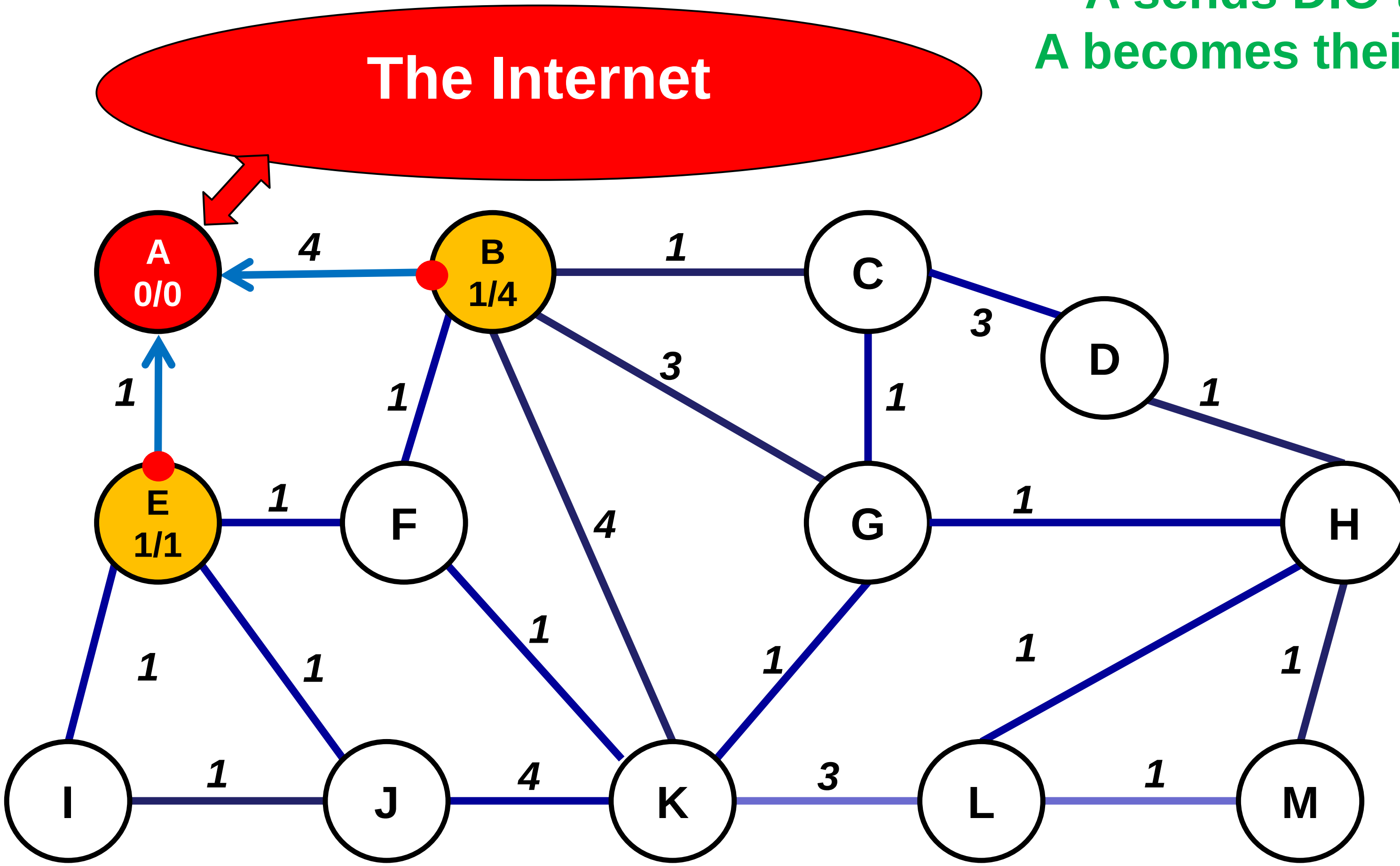
Routing in sensor networks(1).



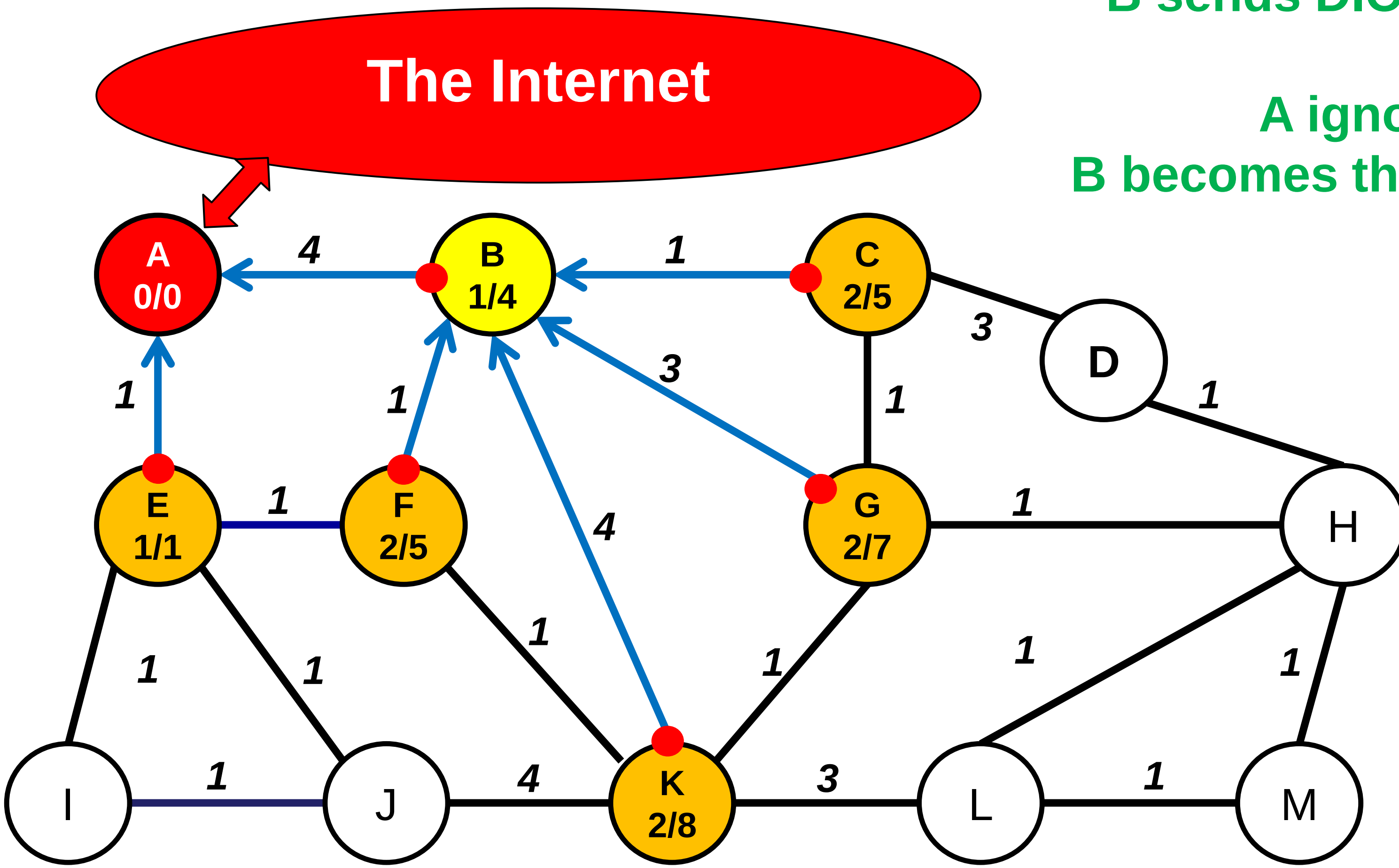
For this example, links have a distance as in DV and AODV. The Rank calculations are made so that Rank = hop count

Routing in sensor networks(2).

A sends DIO to B and E.
A becomes their preferred parent.



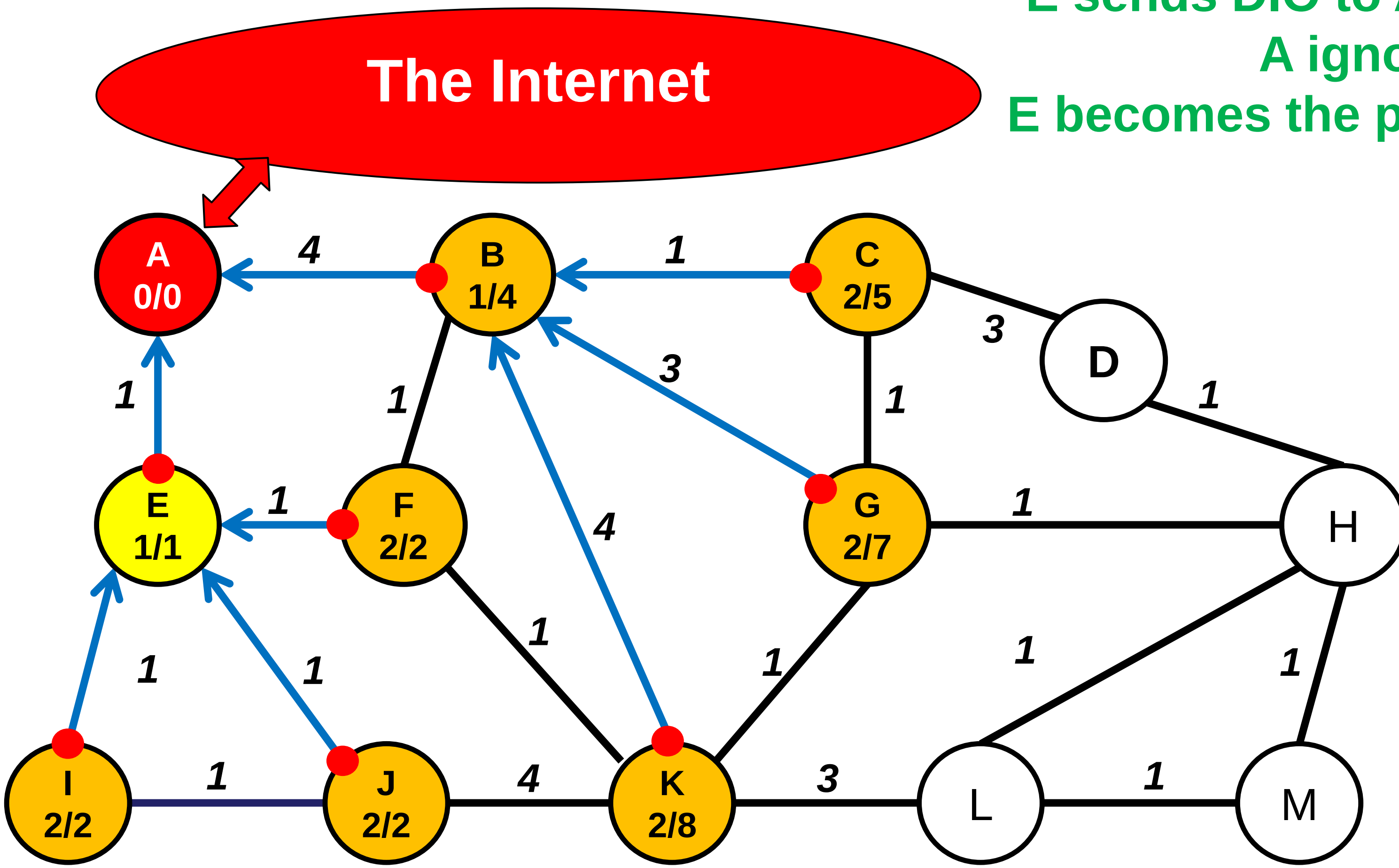
Routing in sensor networks(3).



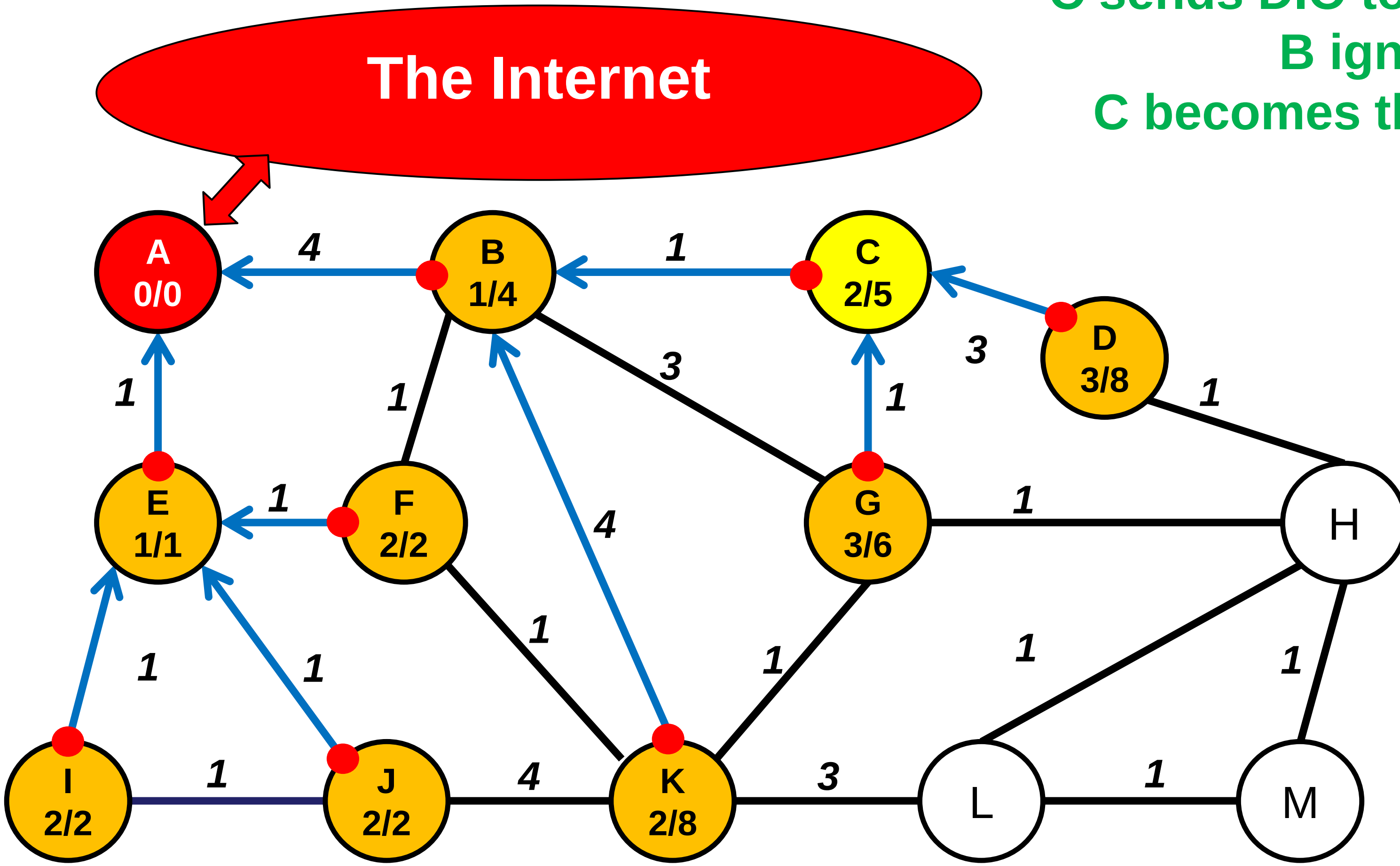
B sends DIO to A,C,F,G and K.
A ignores (rank).
B becomes the parent of all others.

Routing in sensor networks(4).

E sends DIO to A,F,I and J.
A ignores (rank).
E becomes the parent of F,I and J.



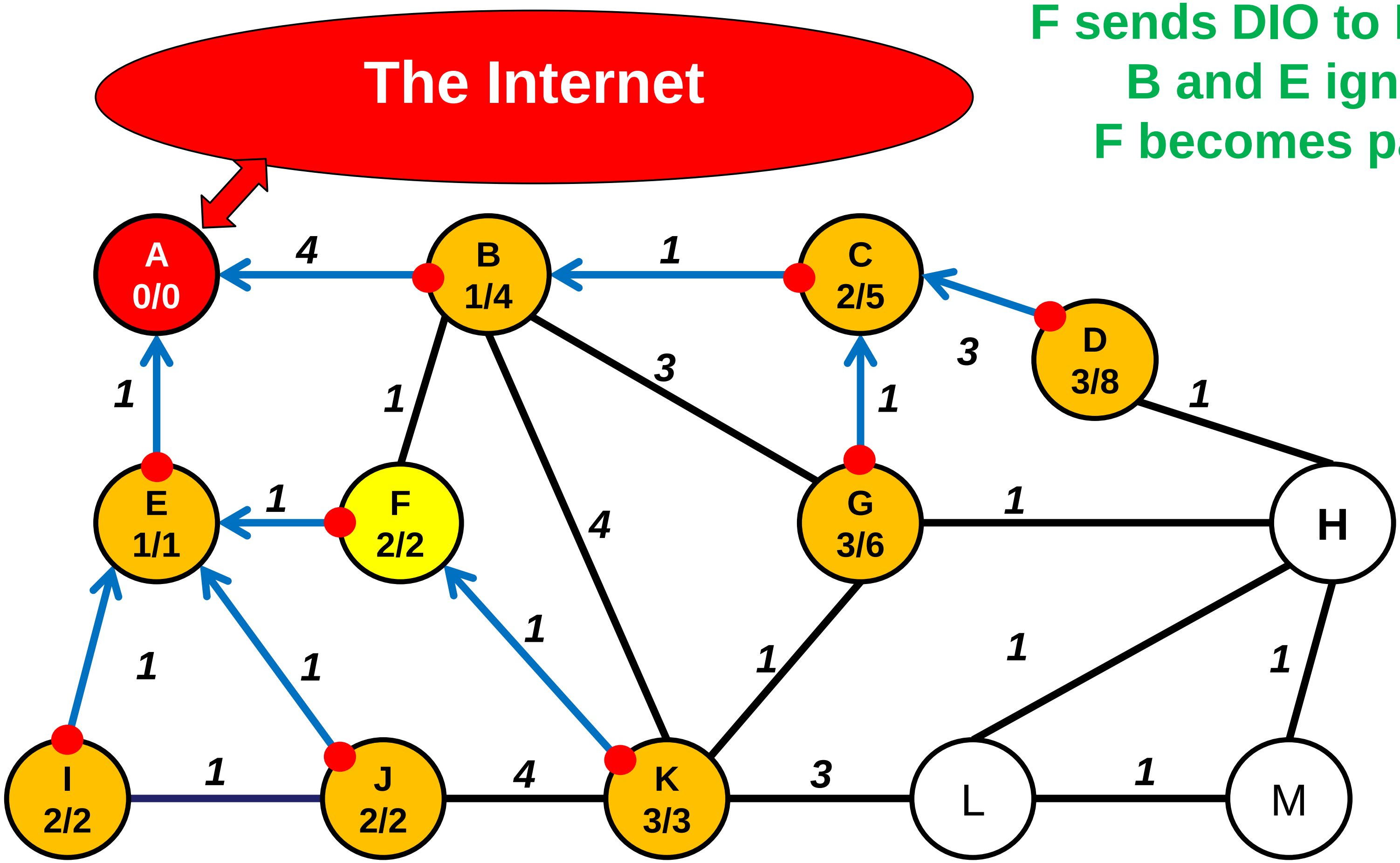
Routing in sensor networks(5).



C sends DIO to B,D and G.
B ignores (rank).
C becomes the parent of D and G.

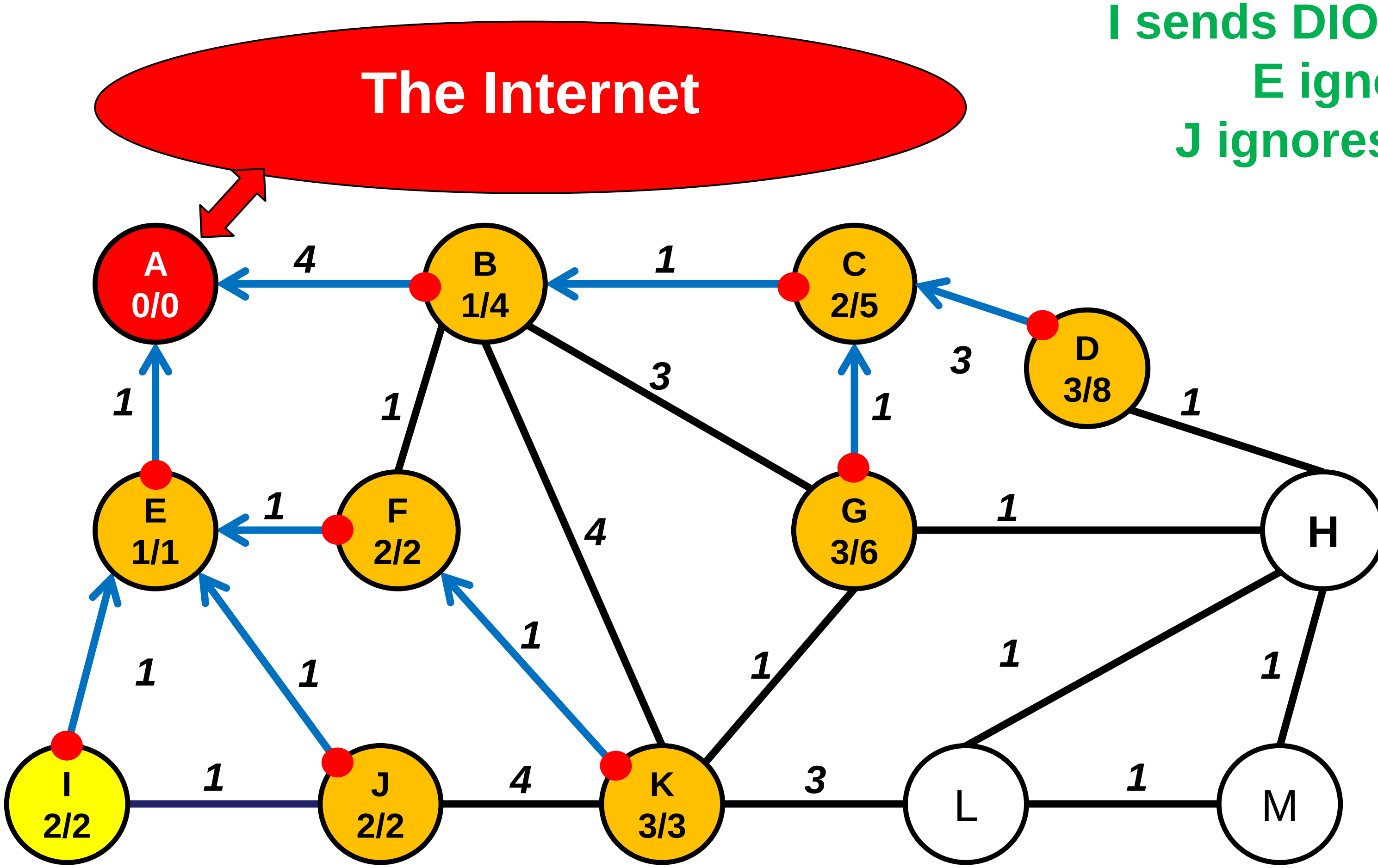
Routing in sensor networks(6).

F sends DIO to B,E and K.
B and E ignore (rank),
F becomes parent of K.



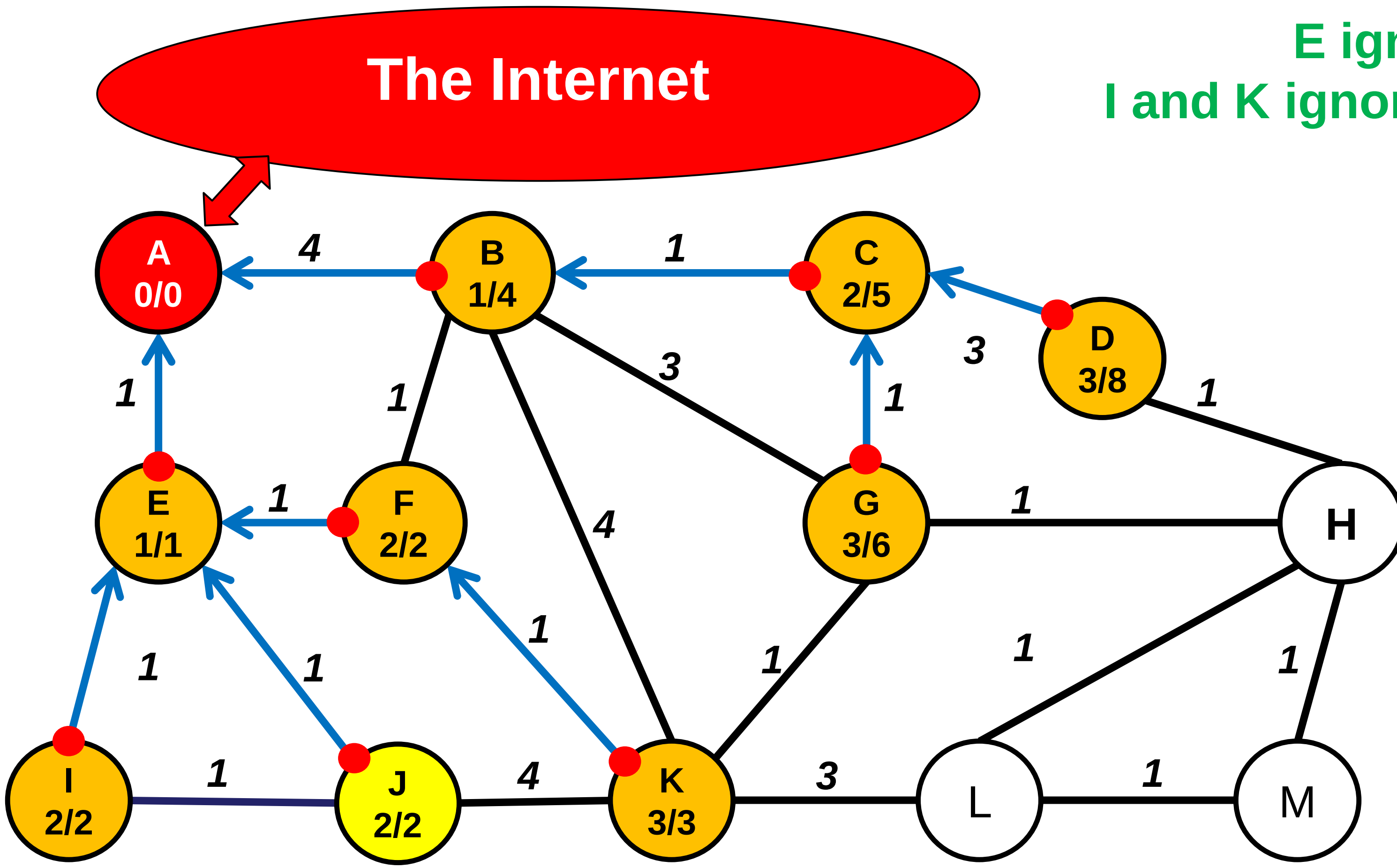
Routing in sensor networks(7).

I sends DIO to E and J.
E ignores (rank),
J ignores (distance)



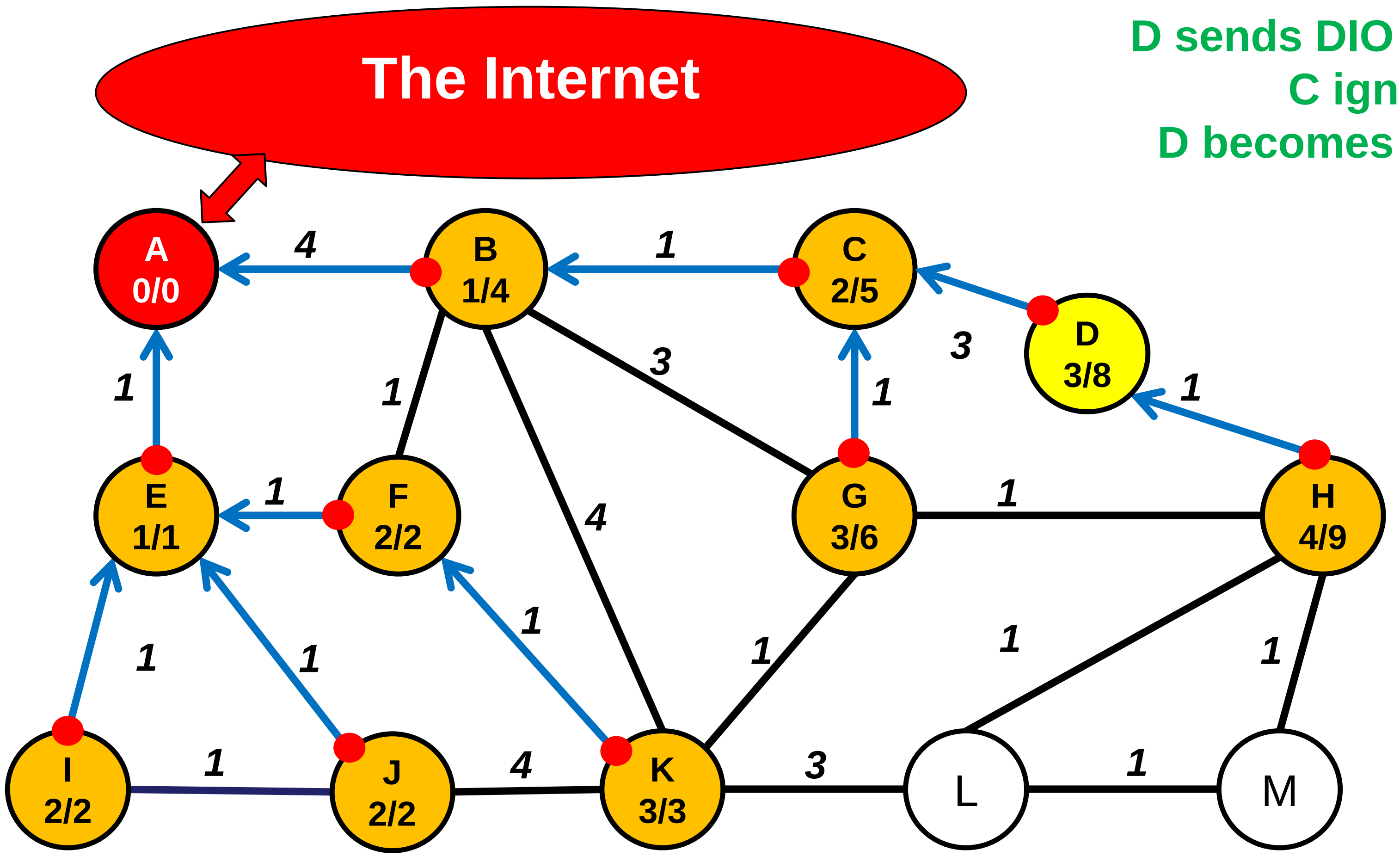
Routing in sensor networks(8).

J sends DIO to E,I and K.
E ignores (rank),
I and K ignore (distance)



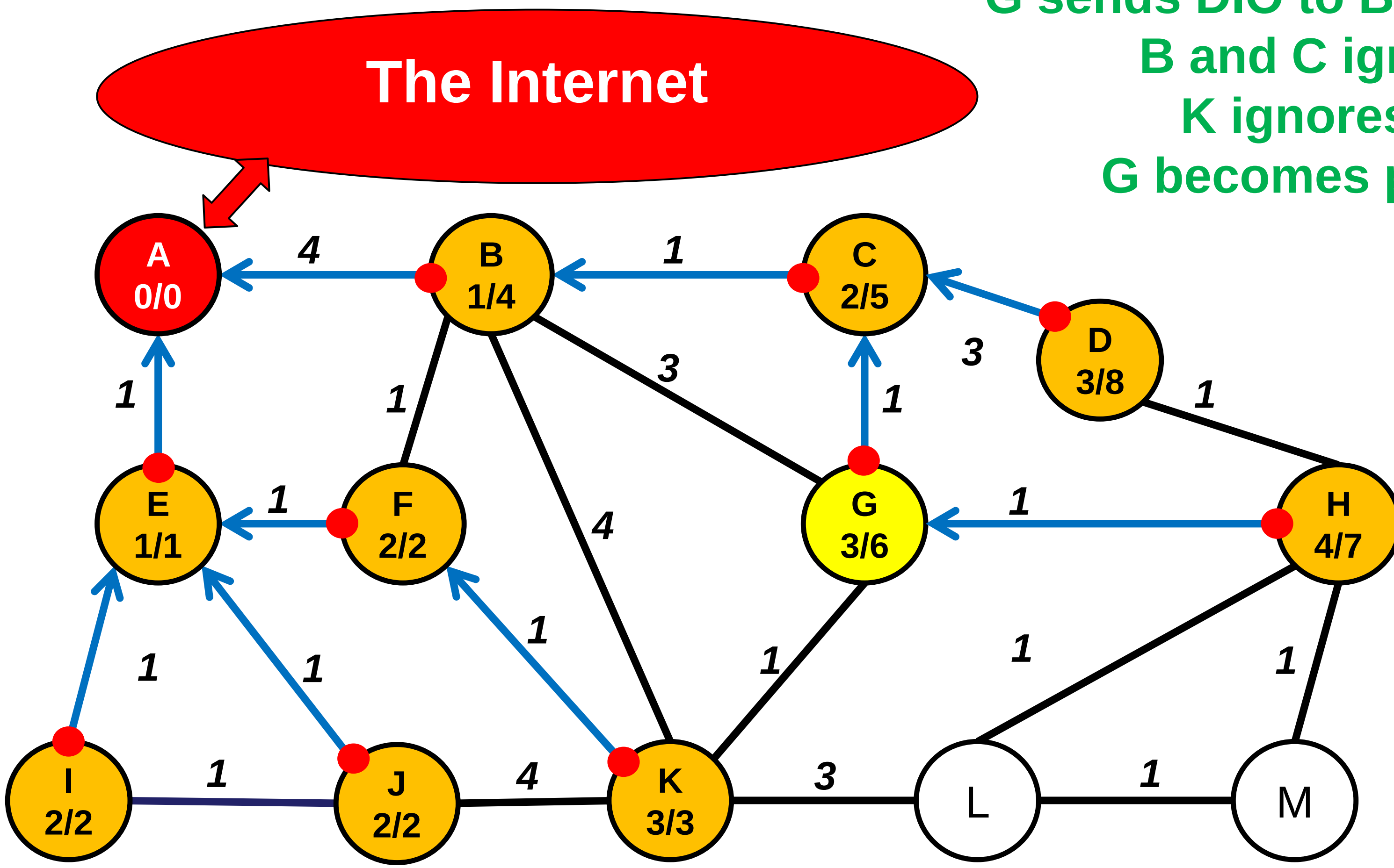
Routing in sensor networks(9).

D sends DIO to C and H.
C ignores (rank),
D becomes parent of H



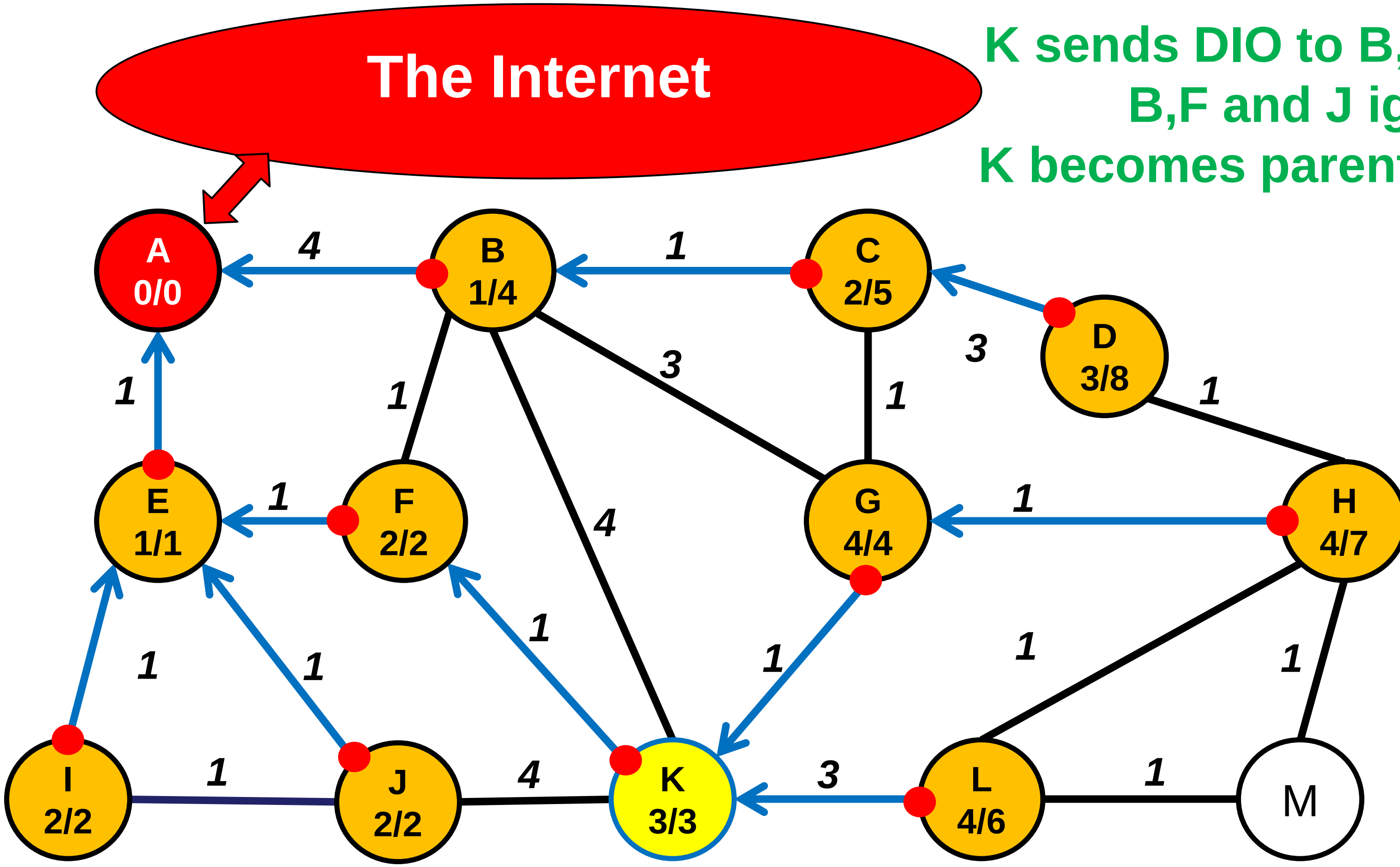
Routing in sensor networks(10).

G sends DIO to B,C,H and K.
B and C ignore (rank),
K ignores (distance)
G becomes parent of H.

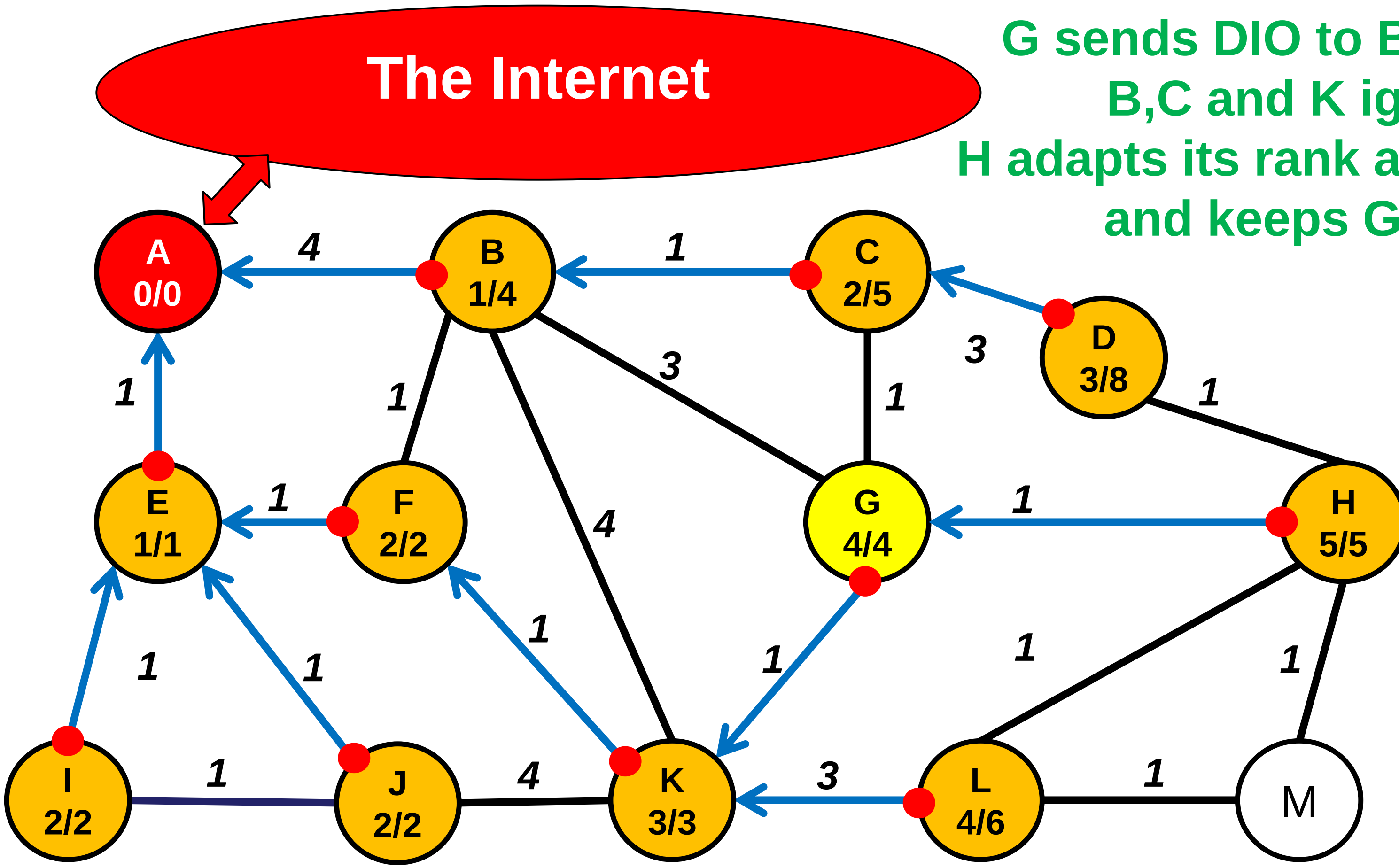


Routing in sensor networks(11).

K sends DIO to B,F,G,J and L.
B,F and J ignore (rank),
K becomes parent of G and L.



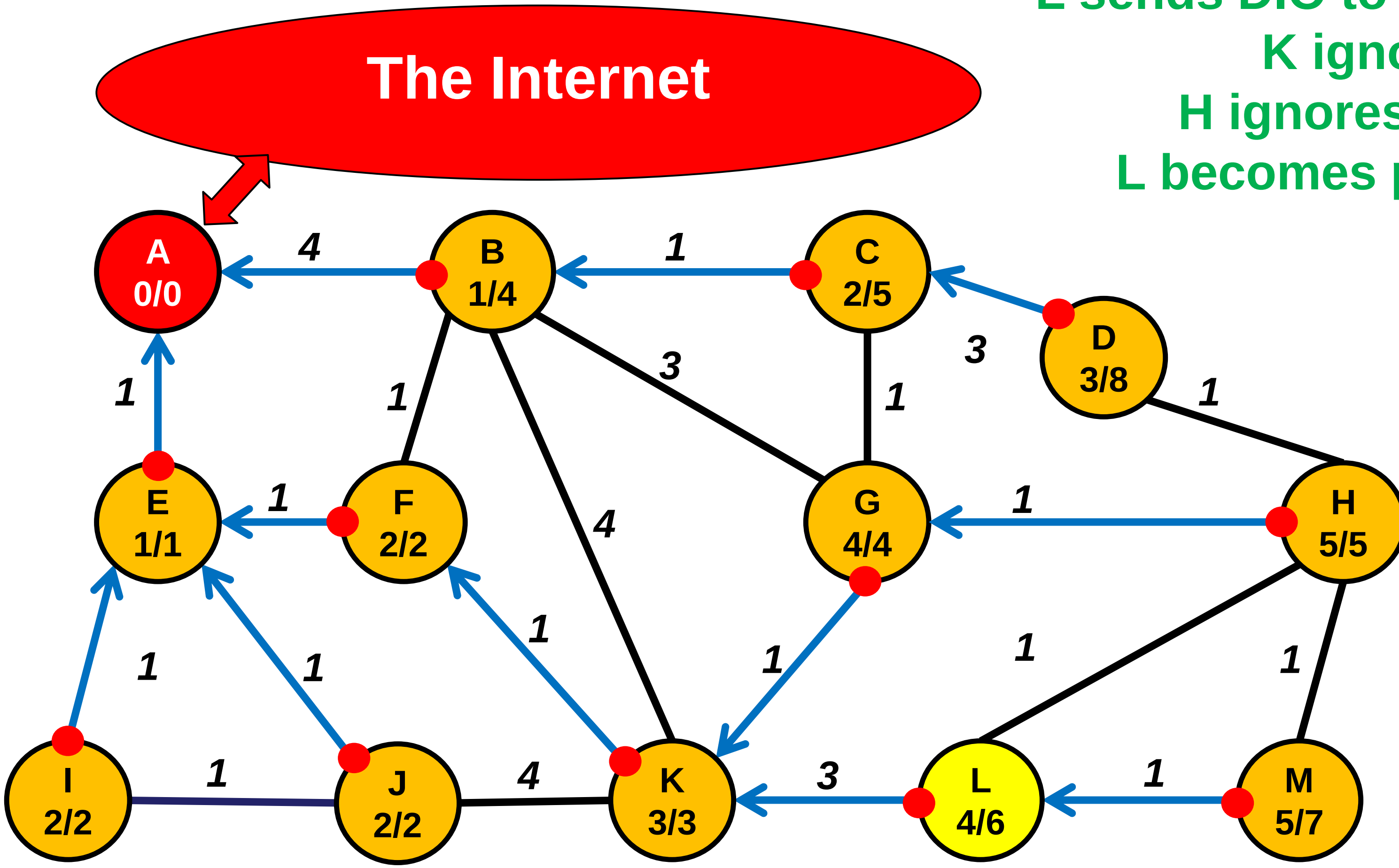
Routing in sensor networks(12).



G sends DIO to B,C,H and K.
B,C and K ignore (rank),
H adapts its rank and distance and keeps G as a parent

Routing in sensor networks(13).

L sends DIO to K,H and M.
K ignores (rank),
H ignores (distance)
L becomes parent of M



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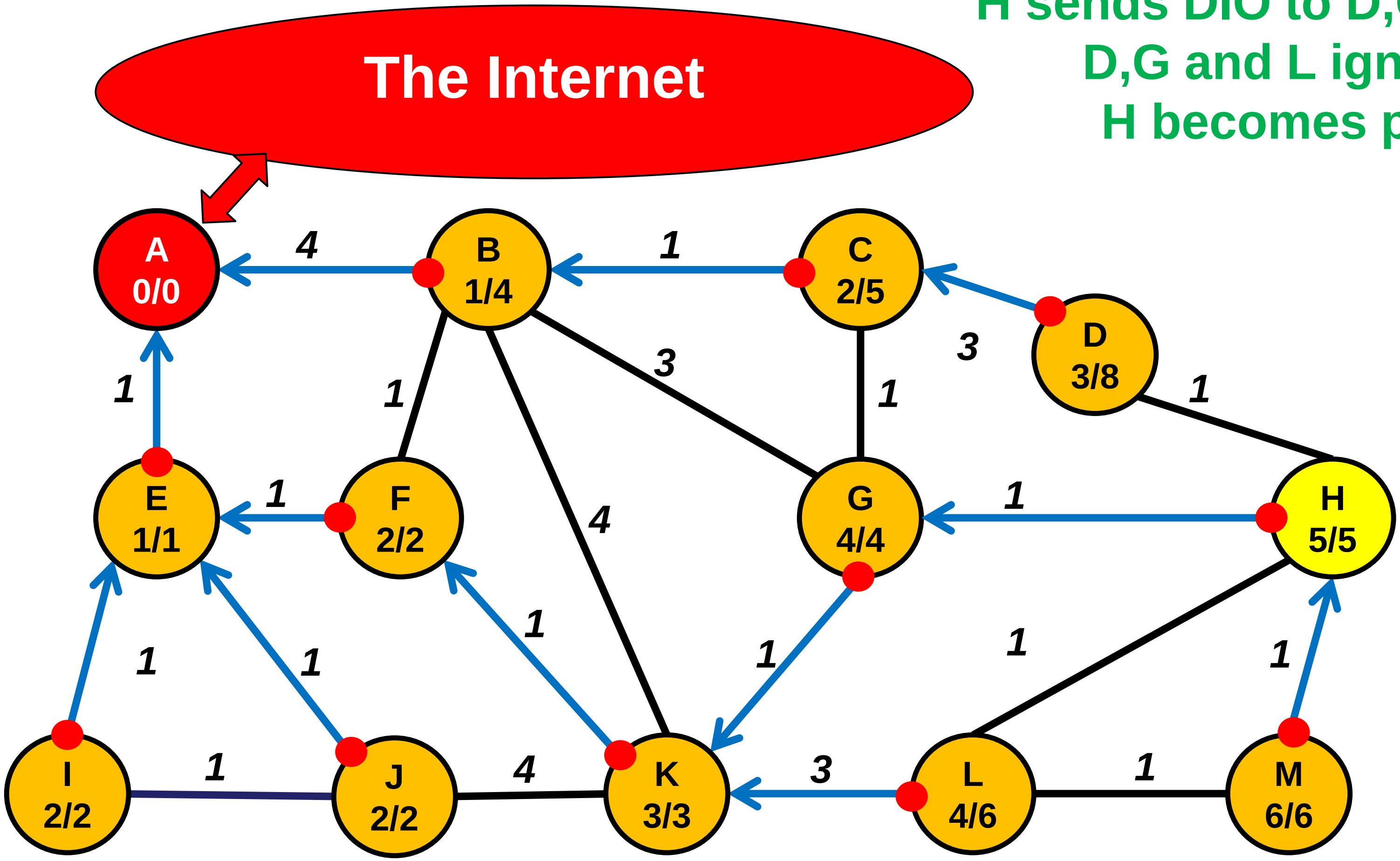
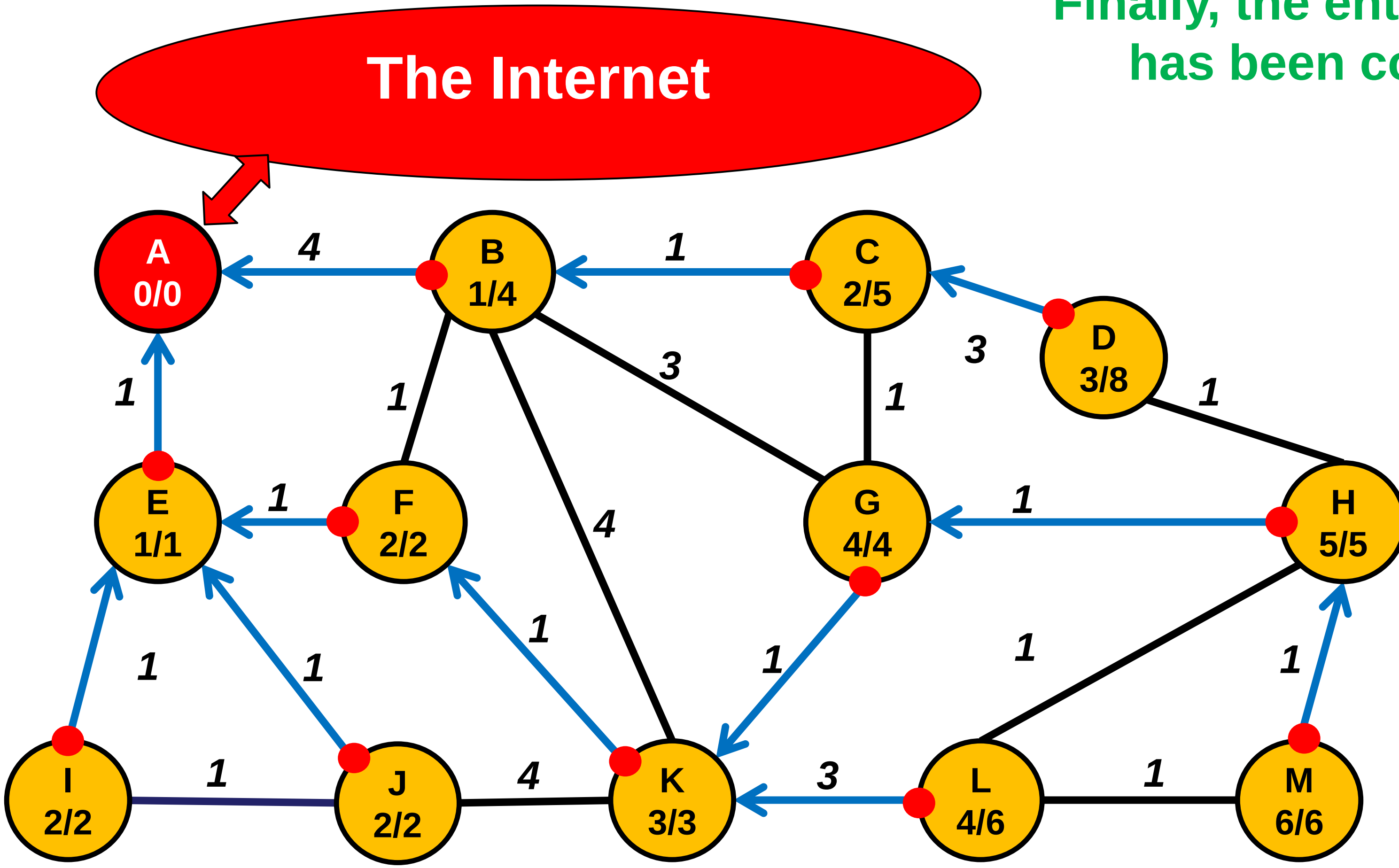
Routing in sensor networks(14).

H sends DIO to D,G,L and M.
D,G and L ignore (rank),
H becomes parent of M



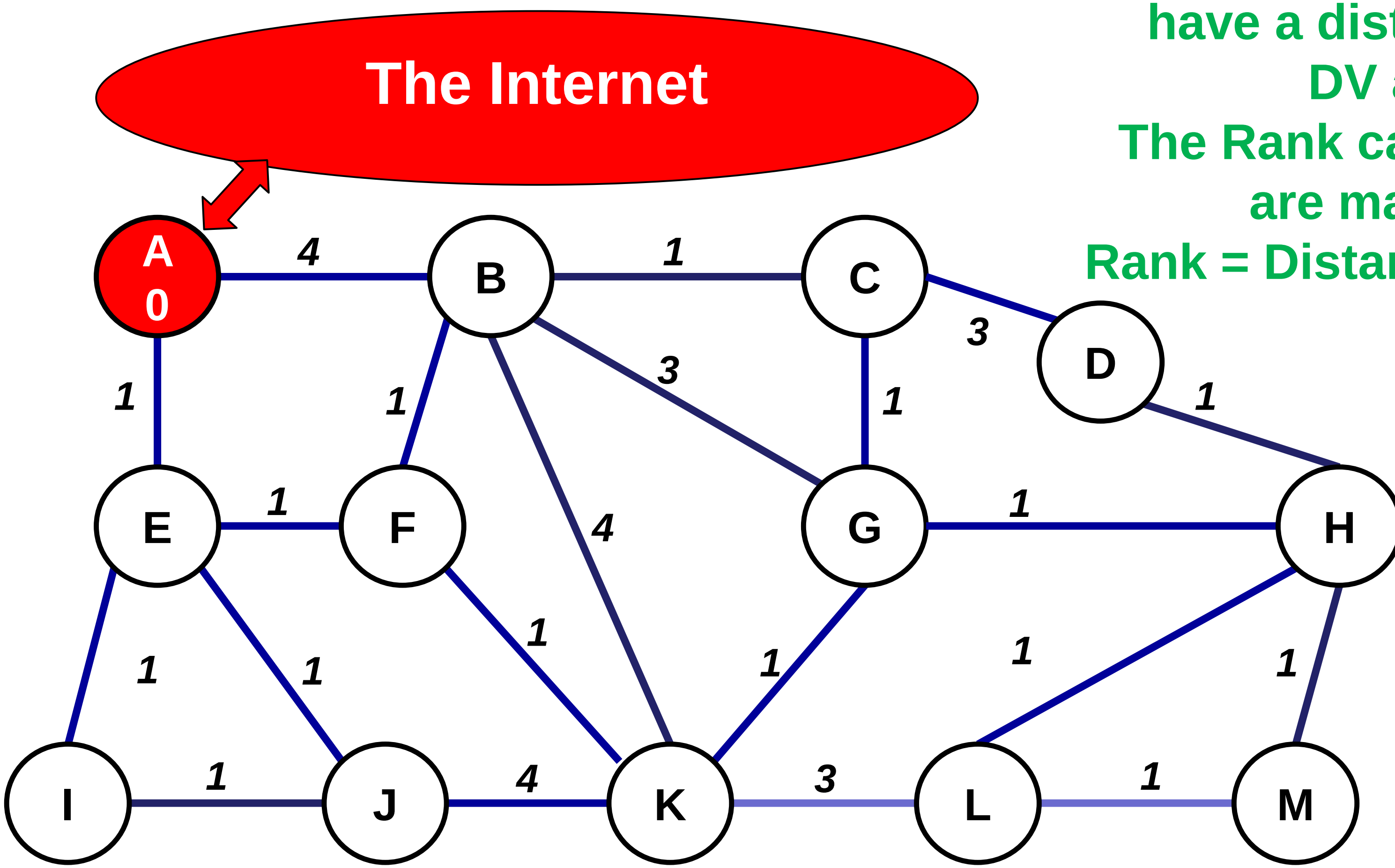
Routing in sensor networks(15).

Finally, the entire DODAG has been constructed.



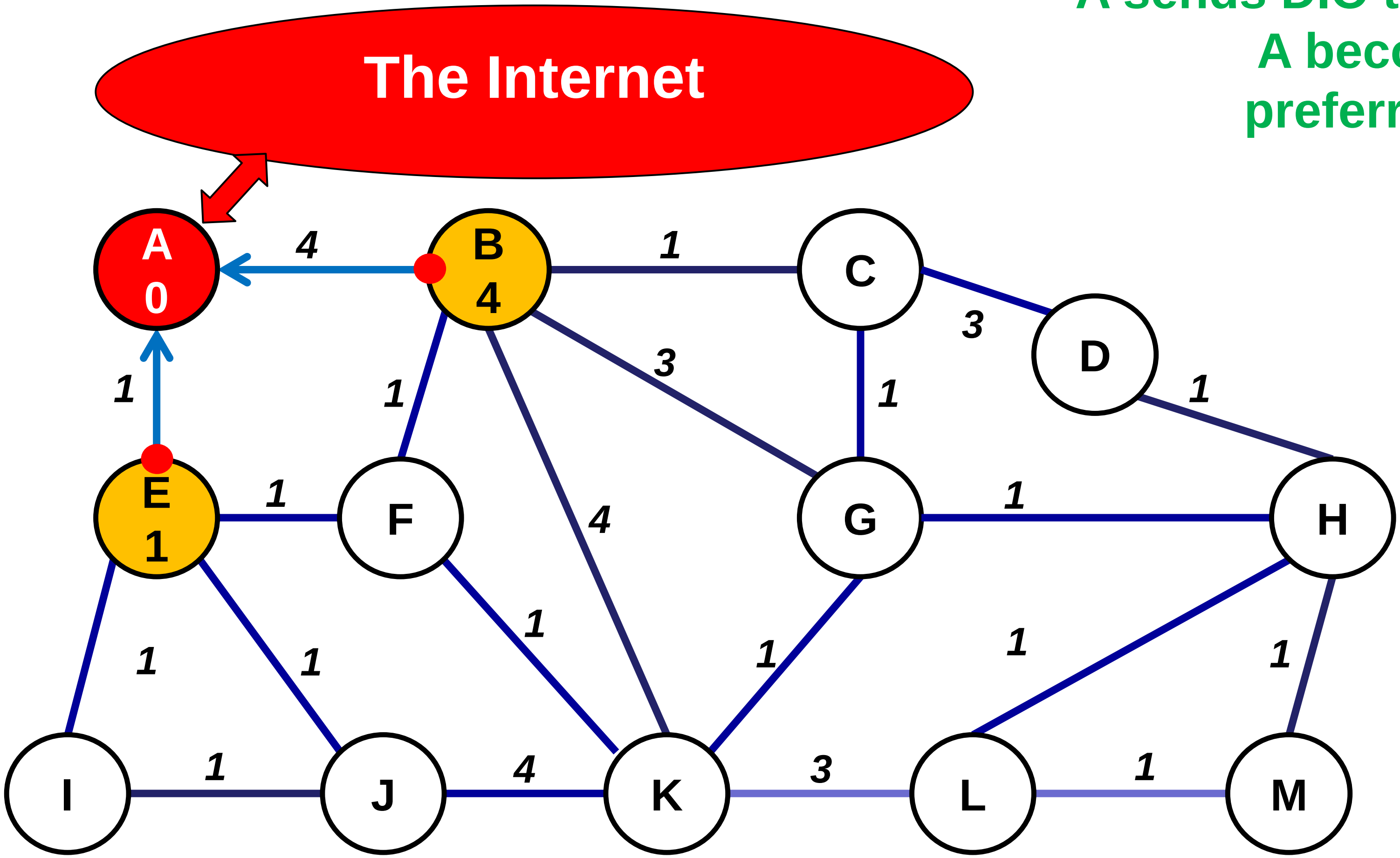
Routing in sensor networks(1’).

**For this example, links have a distance as in DV and AODV.
The Rank calculations are made so that
Rank = Distance to sink**



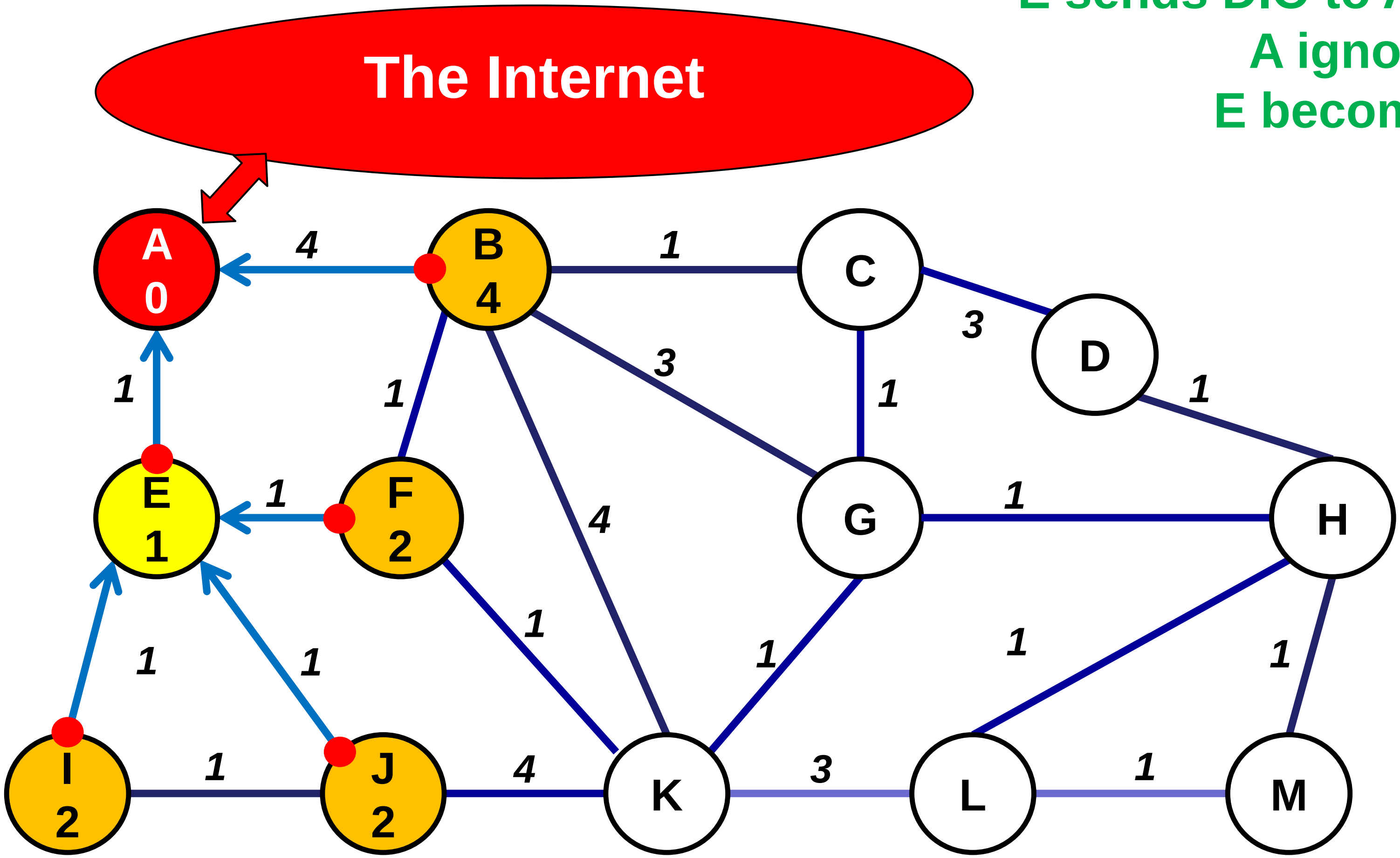
Routing in sensor networks(2’).

**A sends DIO to B and E.
A becomes their
preferred parent.**



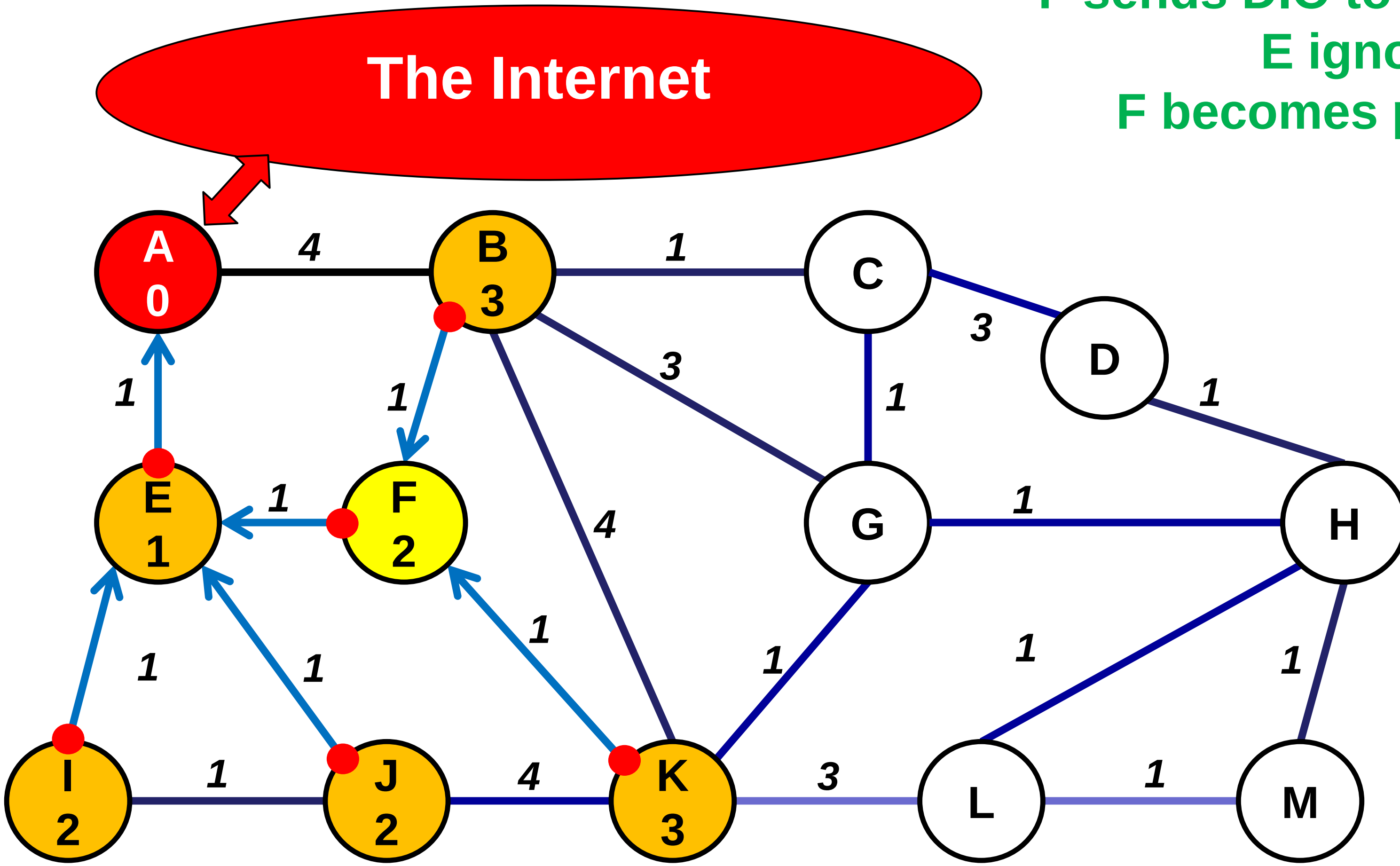
Routing in sensor networks(3’).

E sends DIO to A,F,I and J.
A ignores (rank).
E becomes parent
F,I and J.



Routing in sensor networks(4’).

F sends DIO to B,E and K.
E ignores (rank).
F becomes parent of B and K.



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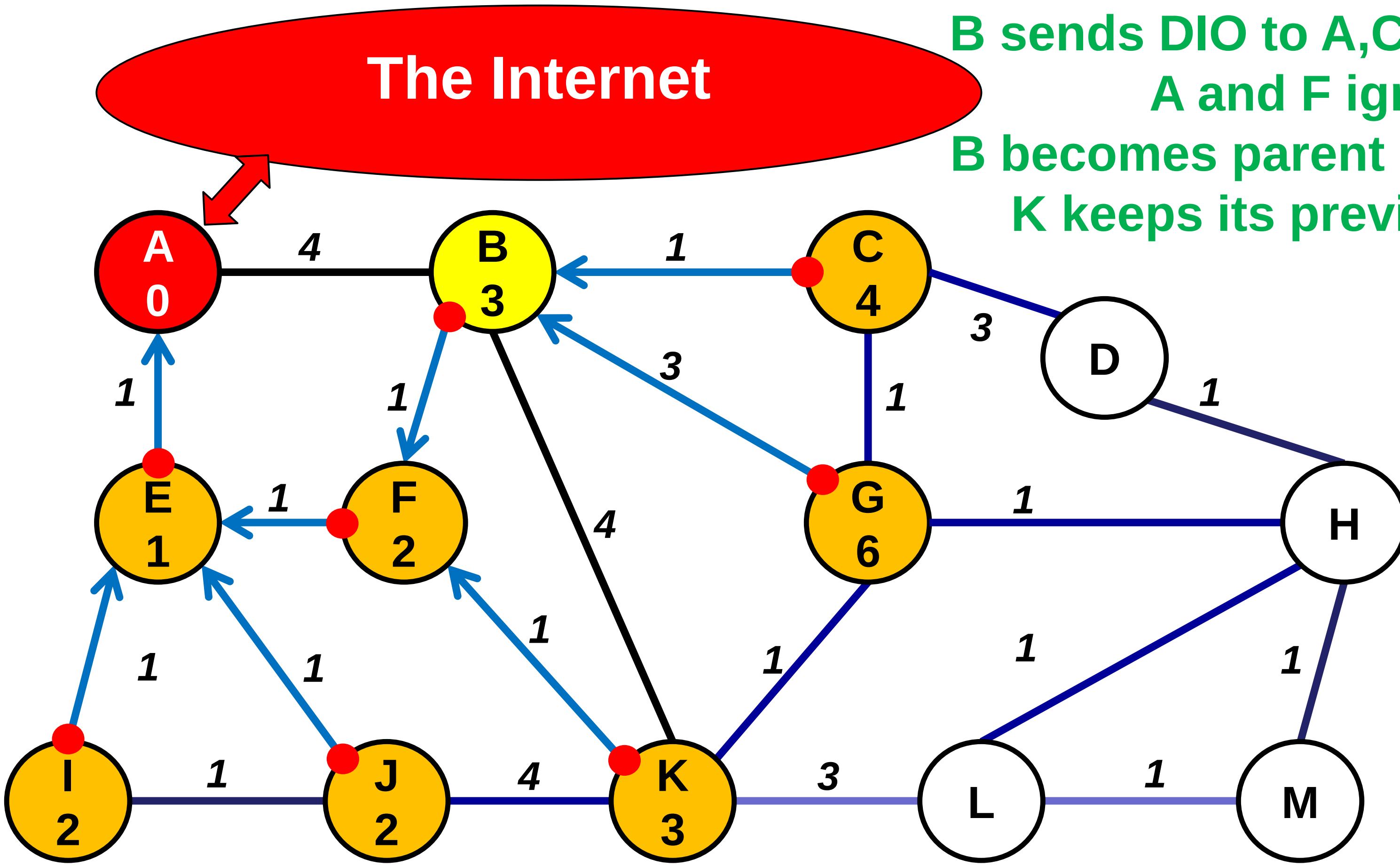
Routing in sensor networks(5’).

B sends DIO to A,C,F,G and K.
A and F ignore (rank).
B becomes parent of C and G.
K keeps its previous parent (distance).



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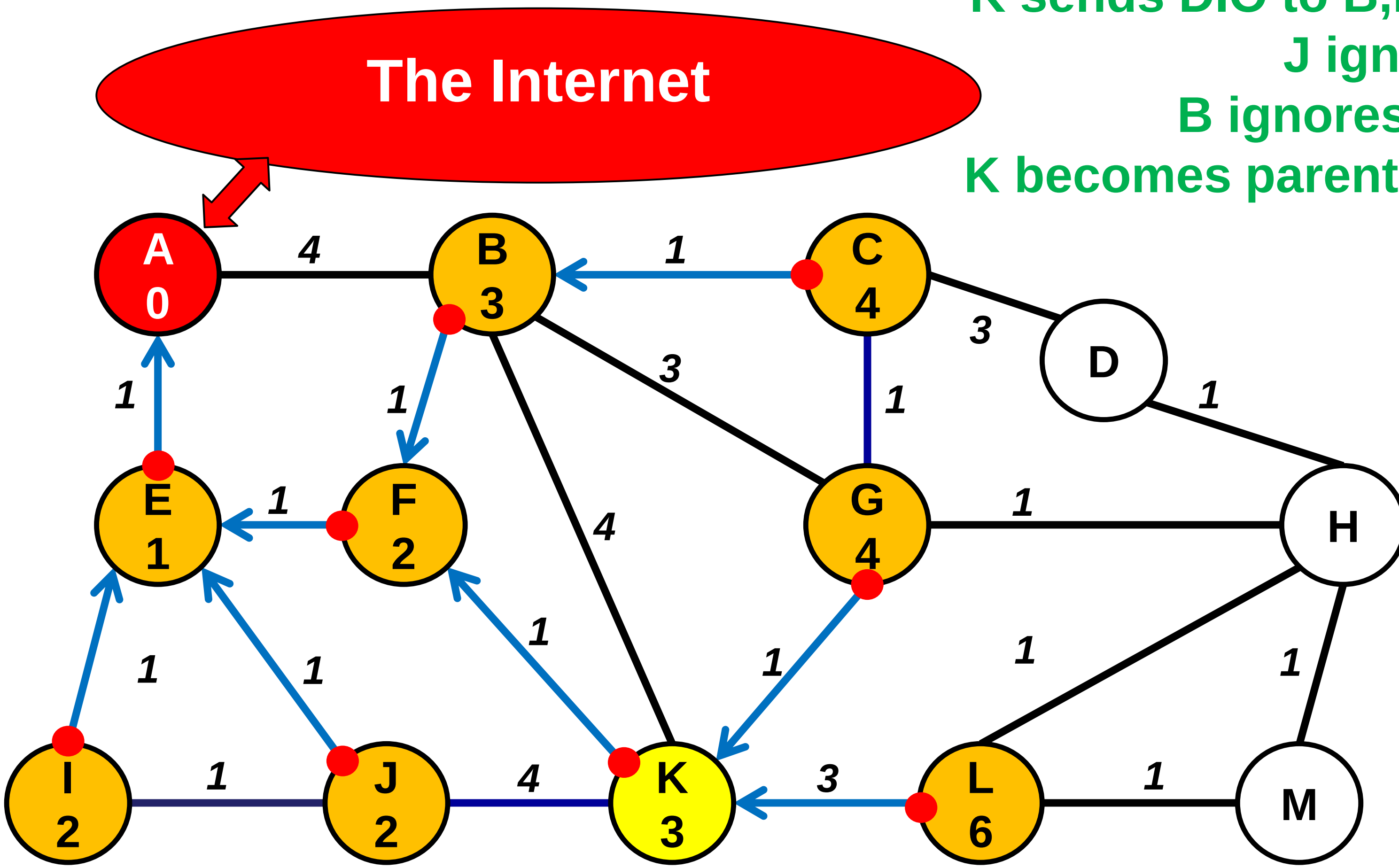
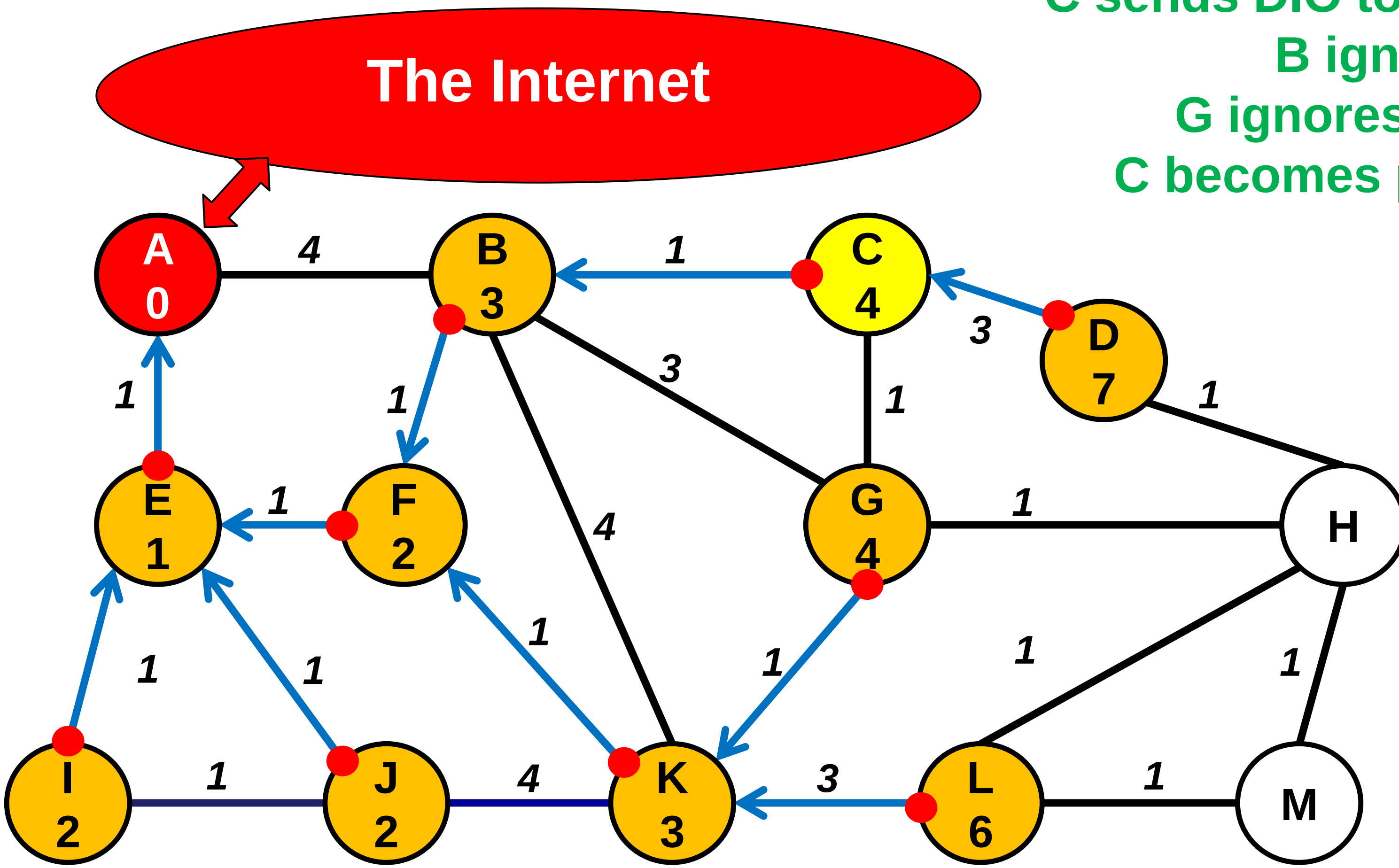
Routing in sensor networks(6').

K sends DIO to B,F,G,J and L.
J ignores (rank),
B ignores (distance),
K becomes parent of G and L.



Routing in sensor networks(7').

C sends DIO to B,D and G.
B ignores (rank),
G ignores (distance),
C becomes parent of D.



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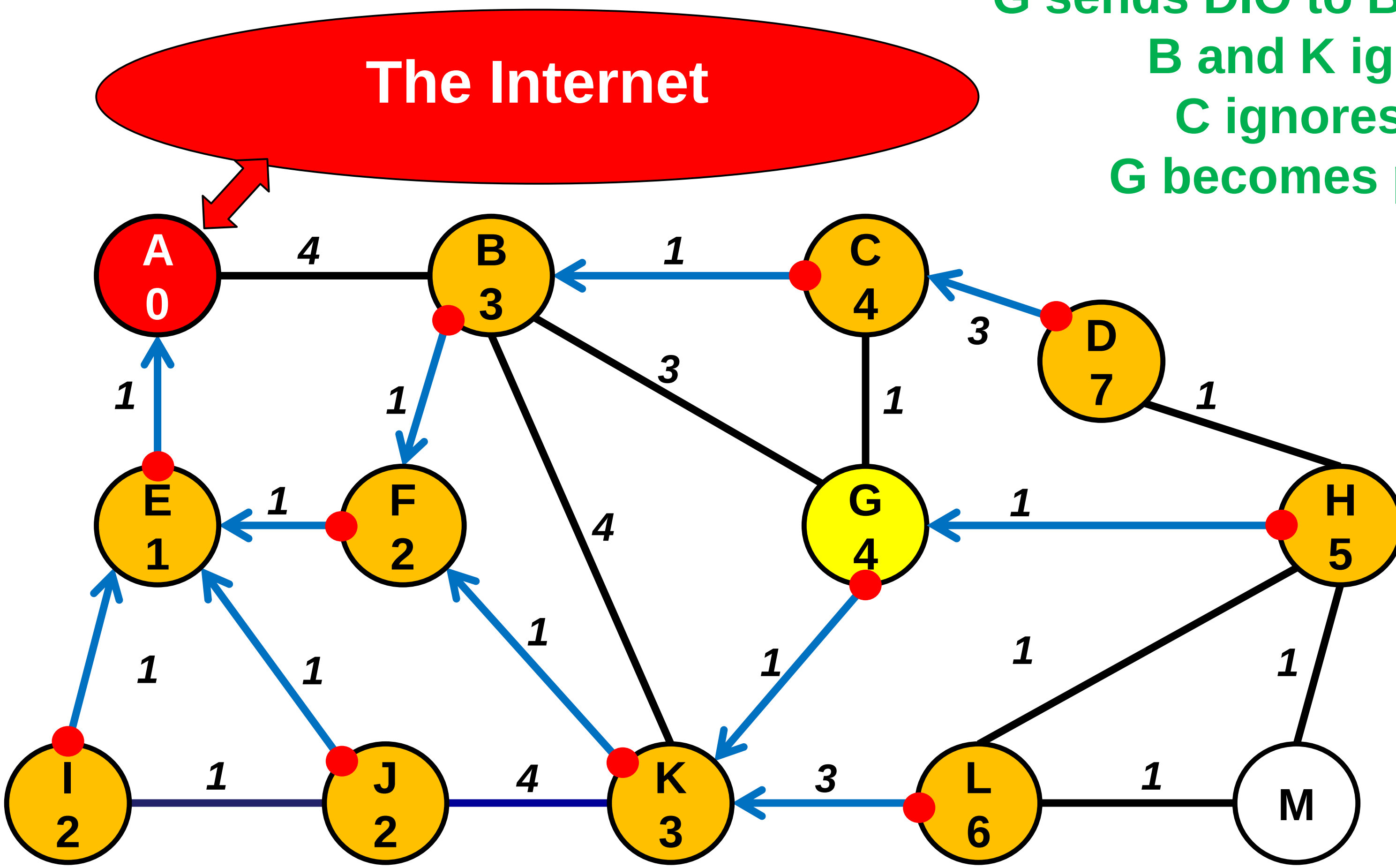
Routing in sensor networks(8’).

G sends DIO to B,C,H and K.
B and K ignore (rank),
C ignores (distance),
G becomes parent of H.



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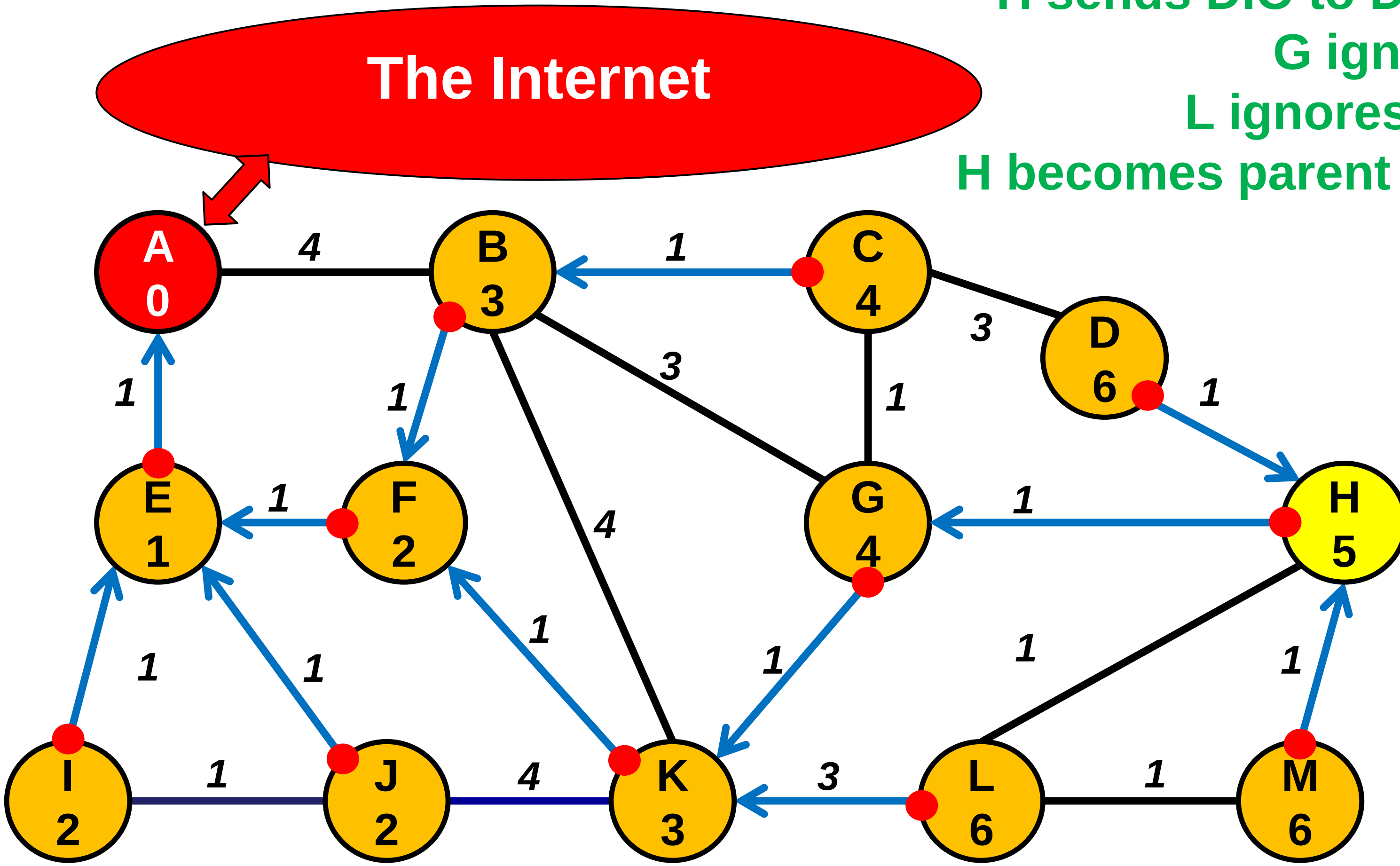
Routing in sensor networks(9').

H sends DIO to D,G,L and M.
G ignores (rank),
L ignores (distance),
H becomes parent of D and M.



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RPL
Conclusions

- **When the network is started up, the DODAG is build.**
- **The DODAG supports optimal routing, both for collect and distribute protocols.**
- **Protocols for detecting network changes and subsequent DODAG repairs (local and global) are part of the RPL proposal (not explained here)**
- **An Objective Function, giving the rank of the nodes in function of the properties of the links and the nodes, can freely be chosen to influence the DODAG topology and prevent loops.**