An Introduction of Cognitive Wireless Networks

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Theoretical Capacity

Theoretical transport capacity of wireless networks is decided by the available network resources:

Spectrum Bandwidth *B;*

Number of Nodes/Radios *N*.

$$C = O(B \cdot \sqrt{N}) \quad bit \cdot meters / \sec$$

It promises to construct large-capacity wireless networks, since both B and N can be large in large-scale networks with unlicensed bandwidth.

How to utilize network resources efficiently?

Traditional Wireless Networking

It is assumed that network resources can be predetermined in network and system design.

Traditional (ad-hoc) wireless networking R&D:

MAC layer establishes logic wired links over wireless medium;

– e.g., MAC of multihop WiFi (IEEE 802.11 DCF).

Inter-node cooperation exhibits at the network layer;

– Diverse design of ad hoc routing protocols: proactive or reactive.

Application traffics are assumed to be uniform, or uncorrelated with the lower-layer design.

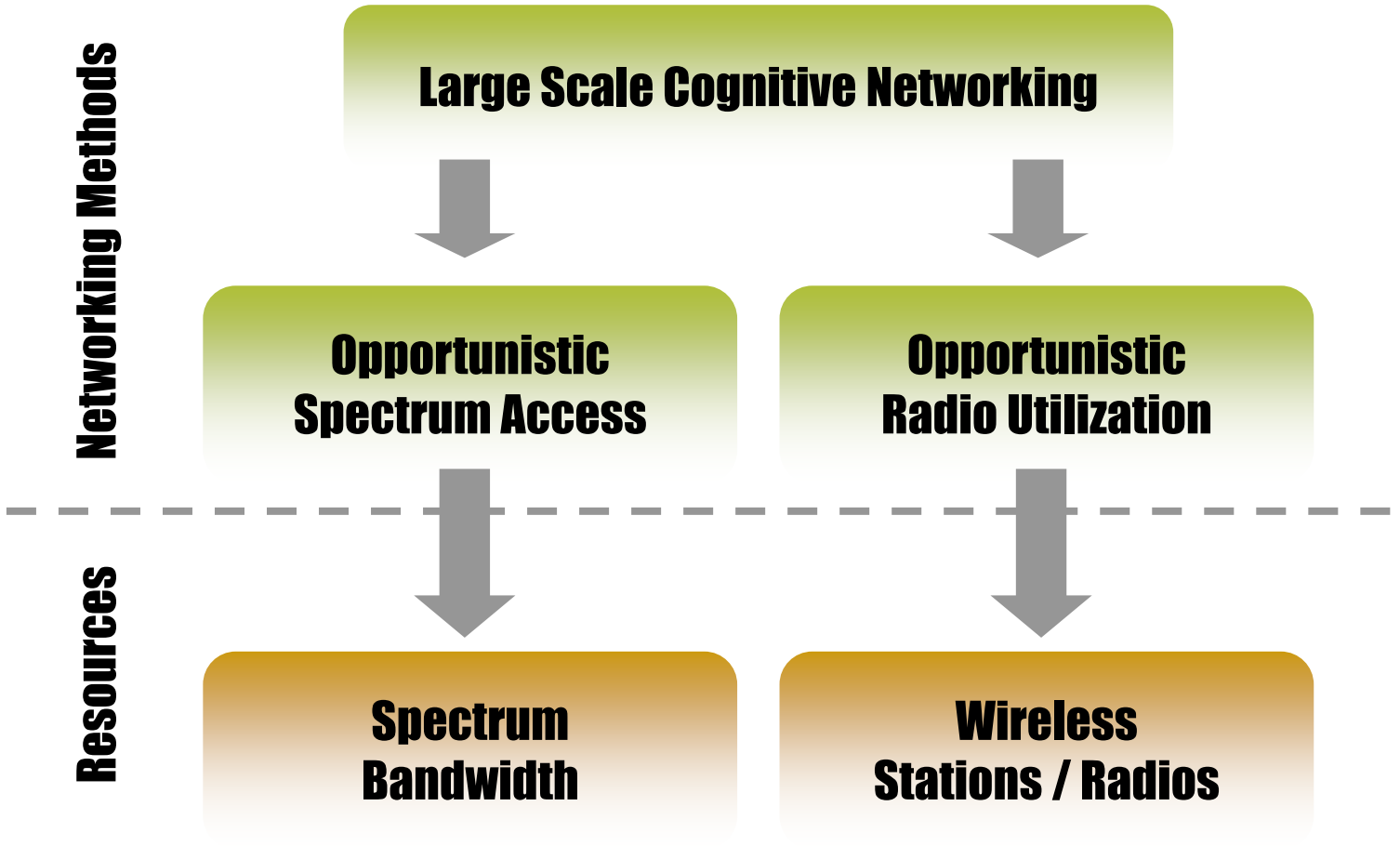
Networking Challenges

	Traffic Volume	Transmission Media
Telephone Networks	Predetermined	Reliable
Current Internet	Dynamic	Reliable
Wireless Networks	Dynamic	Unreliable

Unreliable wireless media and prevailing interferences introduce the *random spectrum availability*;

Dynamic traffic load (congestions), and factors such as node/ radio failures, introduce the *random radio availability*.

Cognitive Networking Concept



Cognitive Networking Concept

Create dynamic wireless networks without predetermined topology or spectrum allocation;

Establish reliable communications for applications in large-scale wireless networks.

Supporting Network Architecture

Redefine (abstract) wireless linkage;

– based on functional abstractions of node/radio cooperation.

Opportunistically handle random networking conditions;

– based on spectrum and radio availability in wireless linkage.

Statistically decouple global QoS criterions into localized criterions.

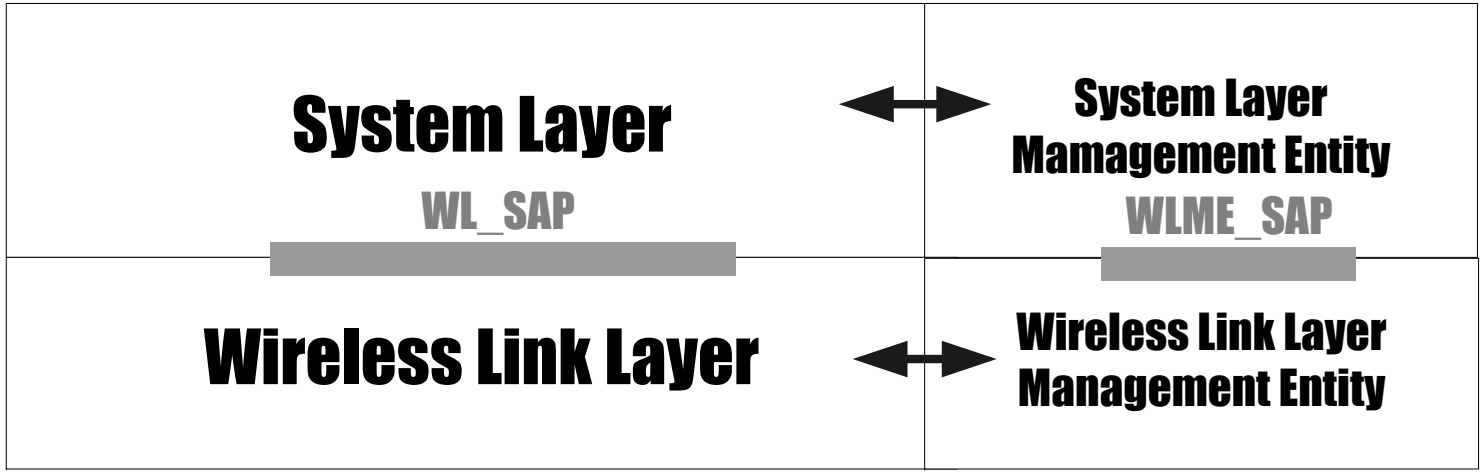
– providing for effective application programming interface.

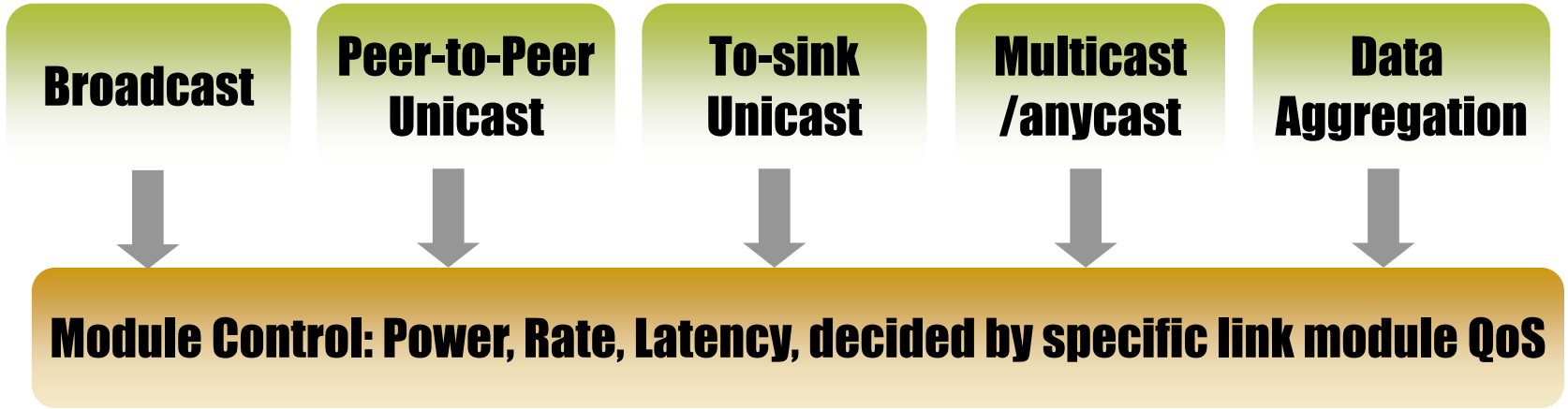
Embedded Wireless Interconnect:

The bottom *Wireless Link layer* supplies a set of abstract wireless link modules to the upper *System layer*;

The *System layer* organizes the provided abstract wireless links to support the application programming.

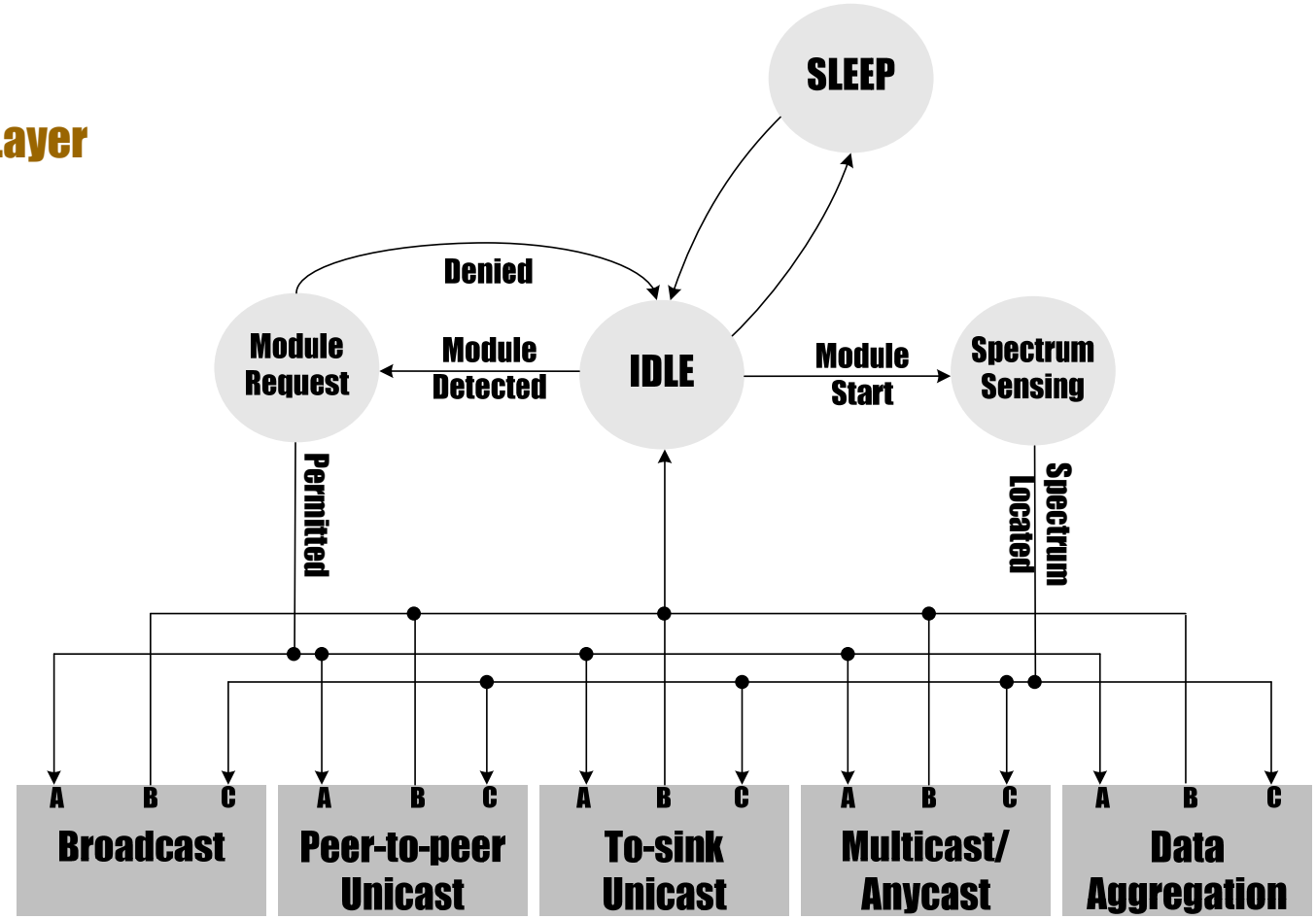
Architecture Diagram



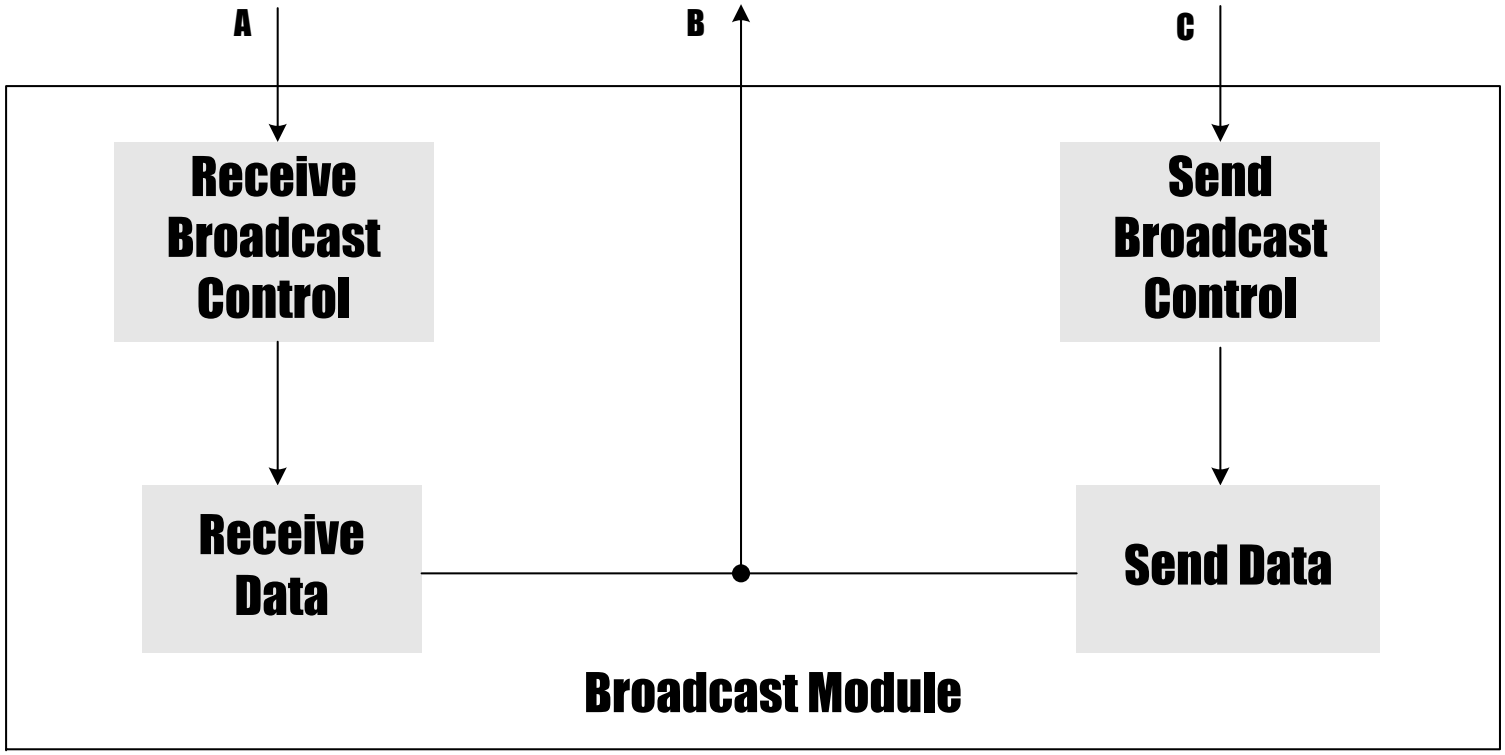


State Diagrams

Wireless Link Layer State Diagram

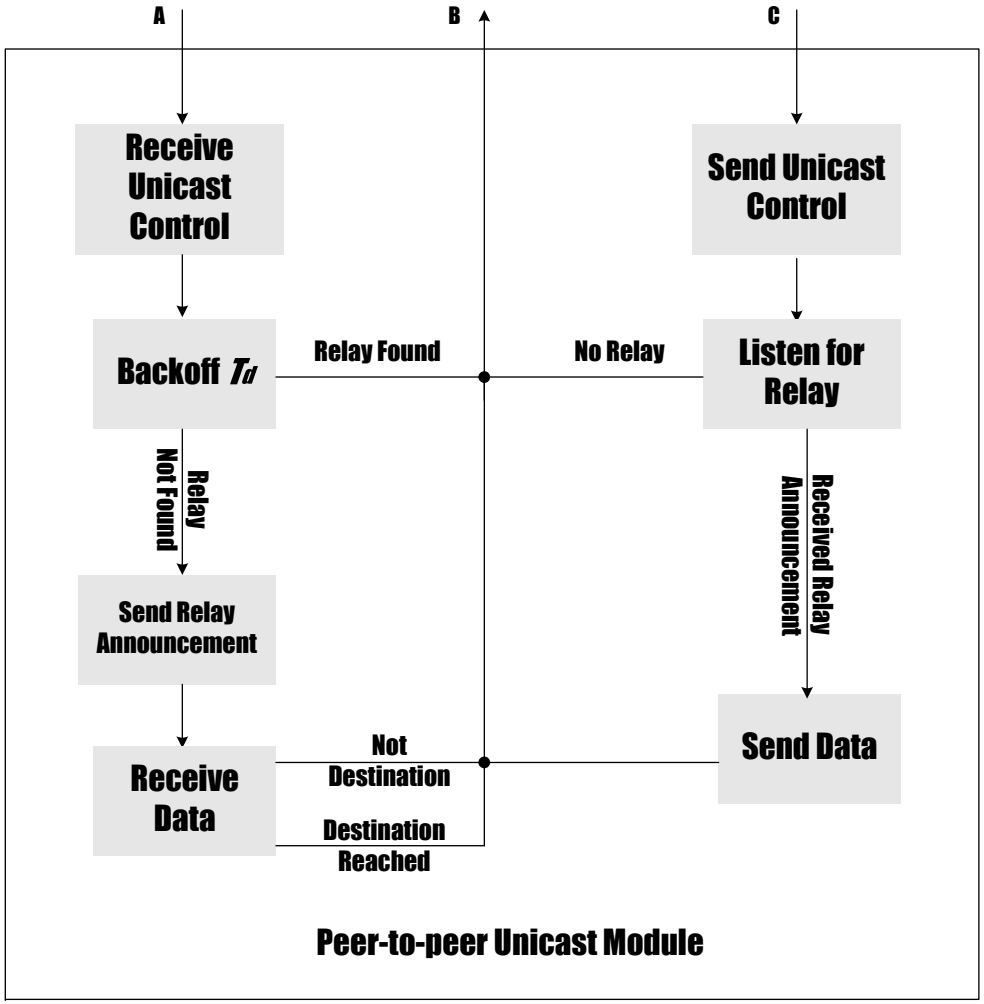


State Diagrams



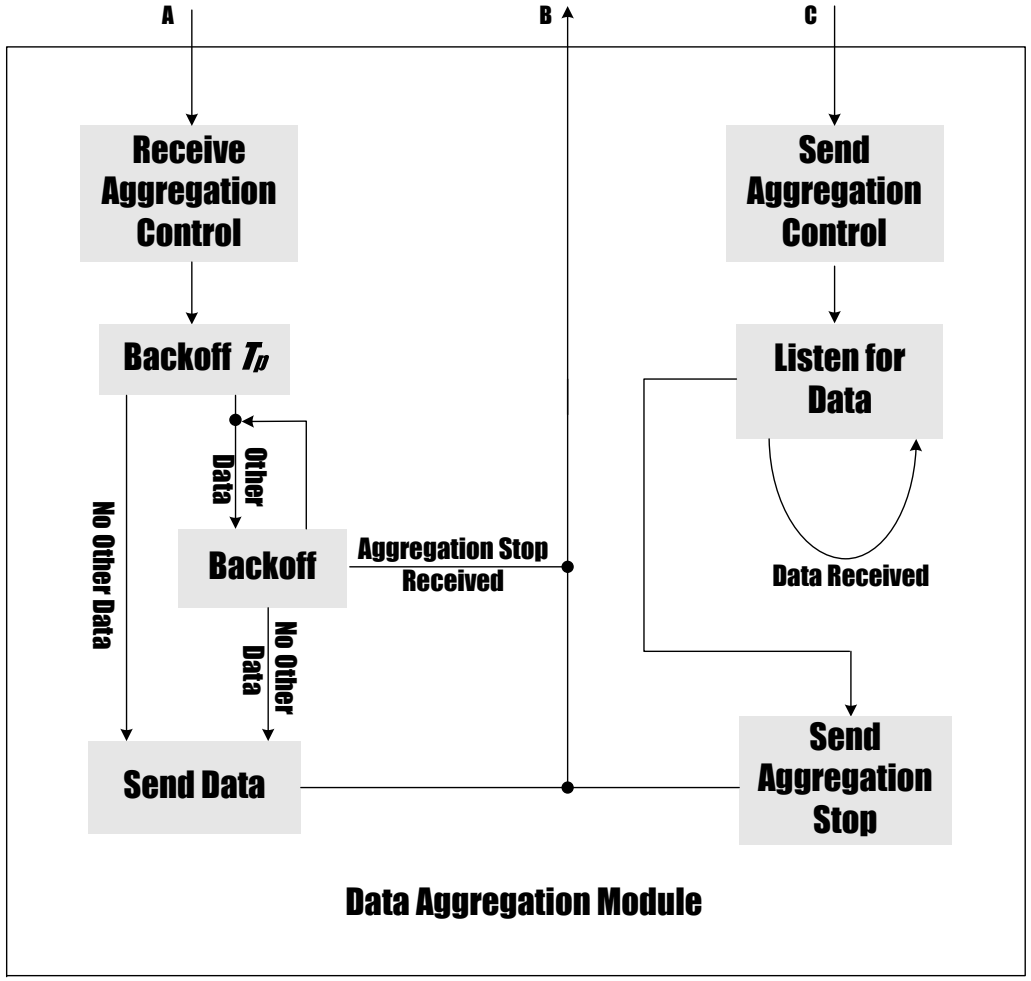
The broadcast wireless link disseminates data among a group of available receivers.

State Diagrams



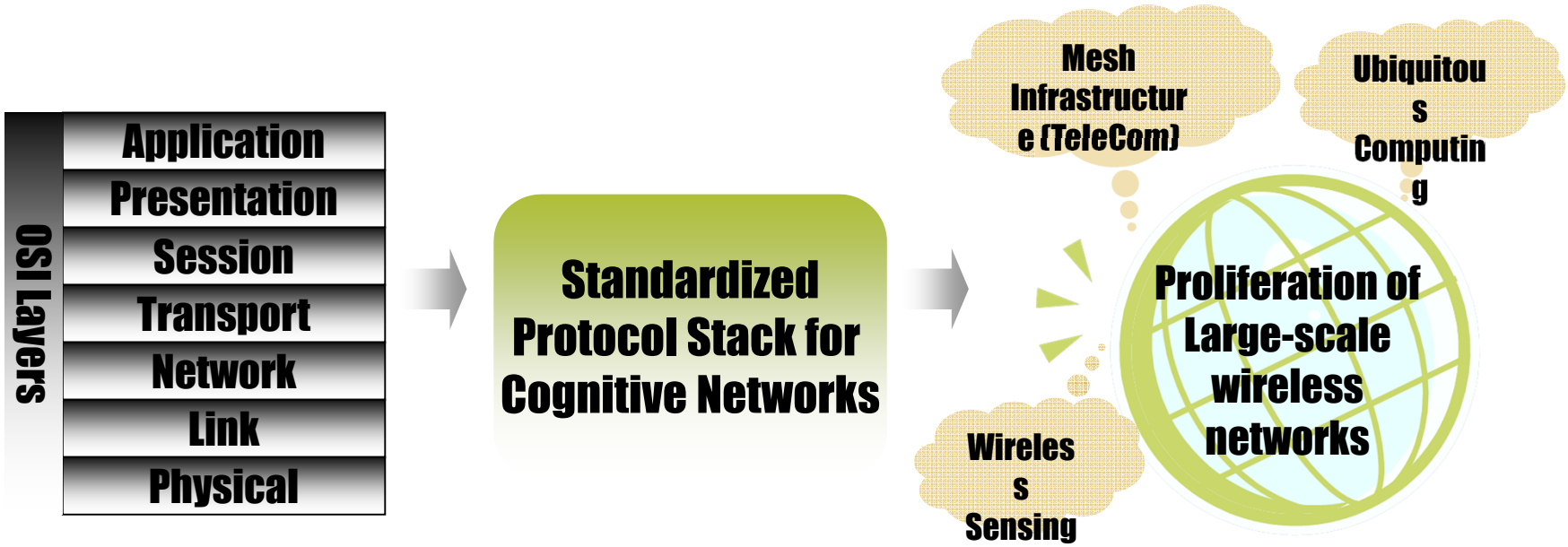
The unicast wireless link elects a relay wireless node for transmitting the data.

State Diagrams



The data-aggregation wireless link opportunistically collects data from a group of available transmitters.

Roadmap



Benefits of Hierarchical Layered Structure:

Converting sophisticated system into simplified layers;

Improving one layer without modifying other layers;

Reusable functionalities.

Advantages

Lower network planning/deployment costs;

– creating dynamic wireless networks without predetermined topology and spectrum allocation.

Better network resource utilization;

– approaching the capacity of wireless networks.

Providing for reliable wireless multi-hop Quality of Services;

– supporting voice/video services (e.g., VoIP).

Supporting scalable wireless node complexity;

– suitable for low power wireless node implementation.

Robust to interferences – ideal for unlicensed spectrum bands;

Compatible with established wireless standards – off-the-shelf.

Conclusions

New networking methods and architecture are needed for dealing with the challenges in large-scale wireless networks and systems;

The concept of *Large Scale Cognitive Networks* opportunistically utilizes network resources including both spectrum bandwidth and wireless station/radio availability, realizing a dynamic wireless network with reliable communications;

The architecture reference model Embedded Wireless Interconnect, can realize the technology concept of cognitive networking. And the reference model also supplements flexible network abstractions for application developments in large-scale wireless systems.