SDR Based Wireless Grid

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Outline

- Introduction
- Research Challenges
  - Reconfiguration
  - Synchronization
- Proposed Algorithm
- An Example
- Summary

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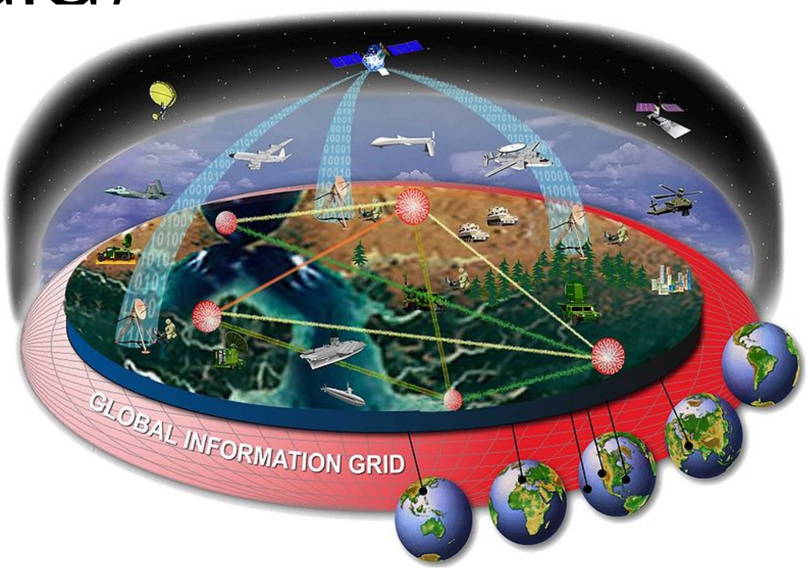
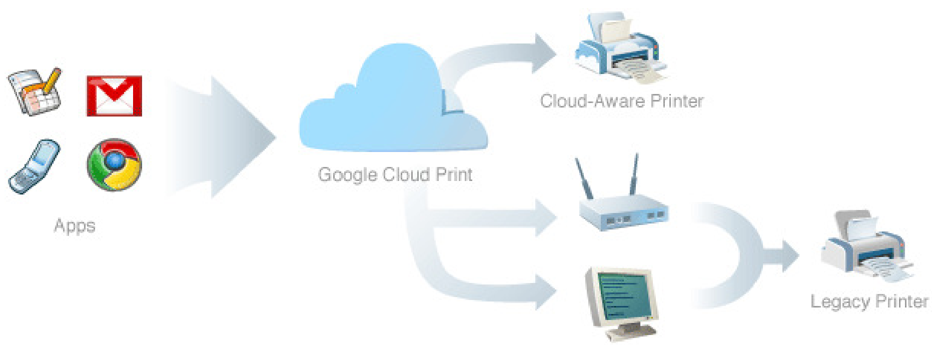
Introduction

- Motivation
  - Progress of wireless communication and computing technologies.
    - Cloud/mobile computing, 4G systems.
  - Evolution of wireless devices.
    - Current smart phone has the comparable capability of desktop we have ten years ago
  - Innovations of the wireless industry.
    - DRSG, D2D, M2M.
- Why WDCN?
  - Service close to users.
  - Potential energy saving and performance improvement, e.g. response time (RT).
  - Lessons learned from PC.

Introduction: Some Examples

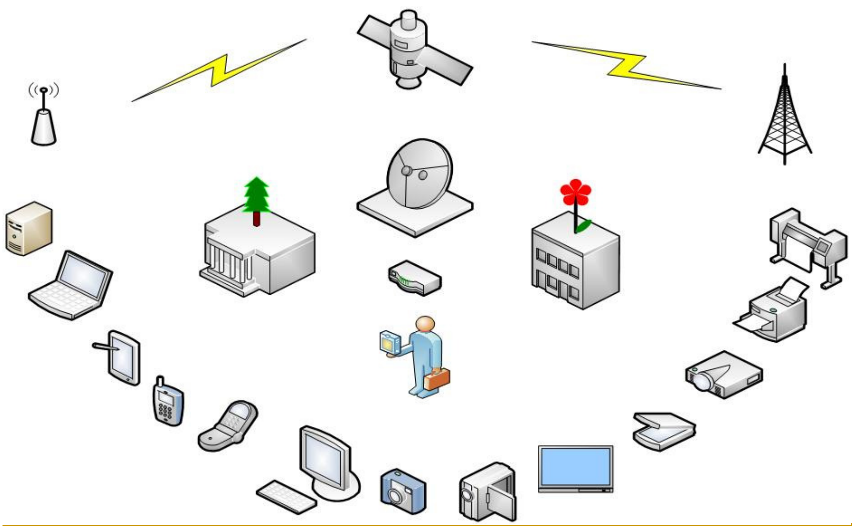
- Cloud Print
- Home Group
- App. Store
- Global Information Grid (GIG)
- Content-share Grid
- WiGiT

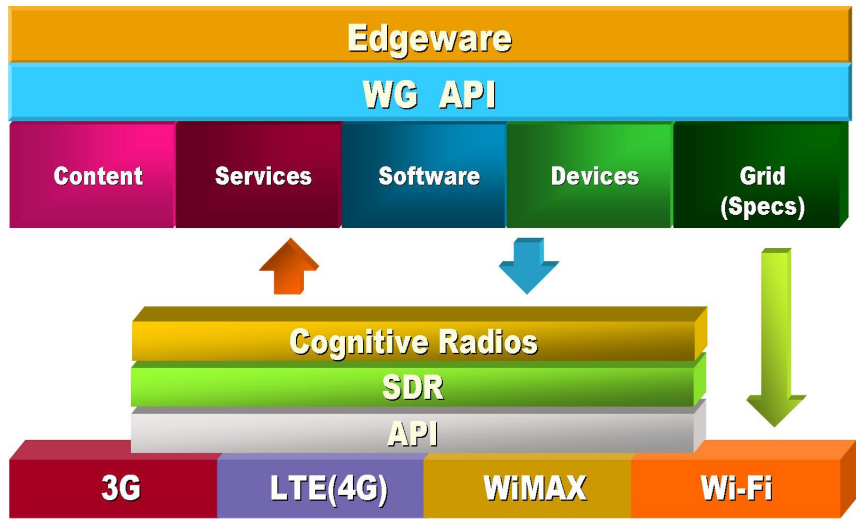




Introduction-Cont.

- Network Model
  - Heterogeneous network.
    - Device, Channel, and Application.
- Node Model
  - SDR for integrating different wireless standards.





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Reconfiguration

- Current Status
  - Hardware
    - small wideband Antenna
    - Low power DSP processor
    - Matching circuits
  - Software:
    - SCA
    - GNU Radio
- Reconfiguration requirement for WG
  - Stability
  - Concurrence
  - Speed
  - Cost
- Synchronization is a building block of a successful reconfiguration for WG.

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Synchronization

- Synchronization for Radios

  Carrier, bit, slot, frame/super-frame, and **protocol**
- Synchronization Skew

  The uncertainty of message delay; the drifts of hardware; and the network diameter and size.
- Requirement for Synchronization

  Validity; Synch. Commit; Correctness; Agreement; Liveness.

Performance Bounds

- A Single Channel

  $\Omega(\log_b D)$ and $\Omega(\sqrt{D})$

- Multiple Channel with Interference

  $\Omega(\ln^2 N/((F-t)\ln\ln N)+Ft\ln N/(F-t))$

- Related Works
  - Reference broadcasting synchronization (RBS)
  - Flooding time synchronization protocol (FTSP)
  - Gradient Synchronization

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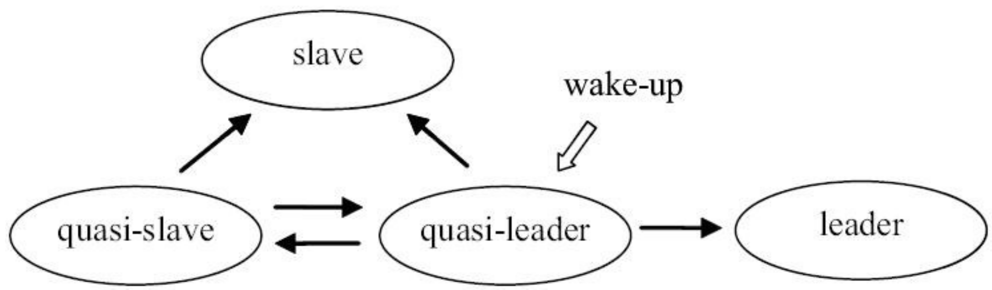
Proposed Algorithm for WG

- Multi-hop and multi-channel with clusters as building blocks.
- Collision destroys the receiving message.
- Interference makes it even worse.
- Simple channel cognition integrated into ALOHA transmission.

Table 1. Frequency Table Update Algorithm

If (collision happens)
Score(i) = Score(i) – (F-1);
Score(j) = Score(j) +1; j ≠ i
q(k) = Score(k)/sum(p(k)); k = 1,2... F.
else if (Rx successfully)
Score(i) = Score(i) + 1;
Score(j) = Score(j) -1; j ≠ i
q(k) = Score(k)/sum(p(k)); k = 1,2... F.
end



Proposed Algorithm

- The optimal Tx probability

$$p = 1 - \sqrt[1-\Delta]{\Delta}$$

where Δ is the network degree.

- The time threshold

$$T_1 = 3\Delta \ln N \quad \text{and} \quad T_2 = 3e\Delta \ln N$$

where T_1: Timer before a node can be promoted

T_2: Timer for leader nodes to terminate the process.

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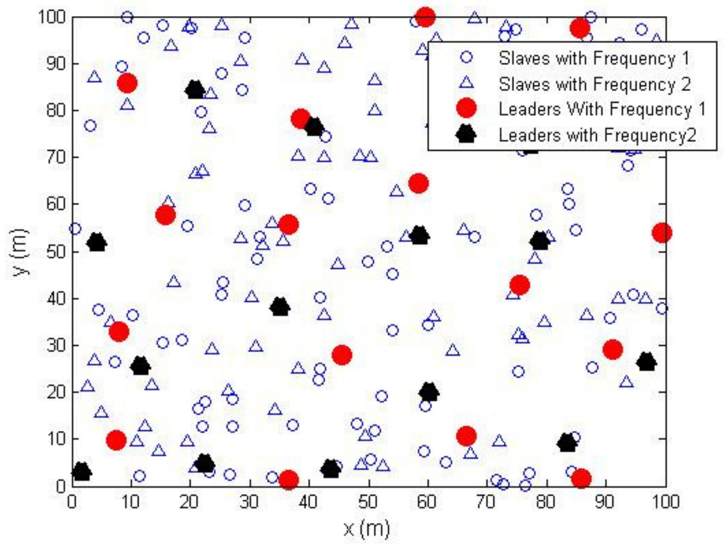
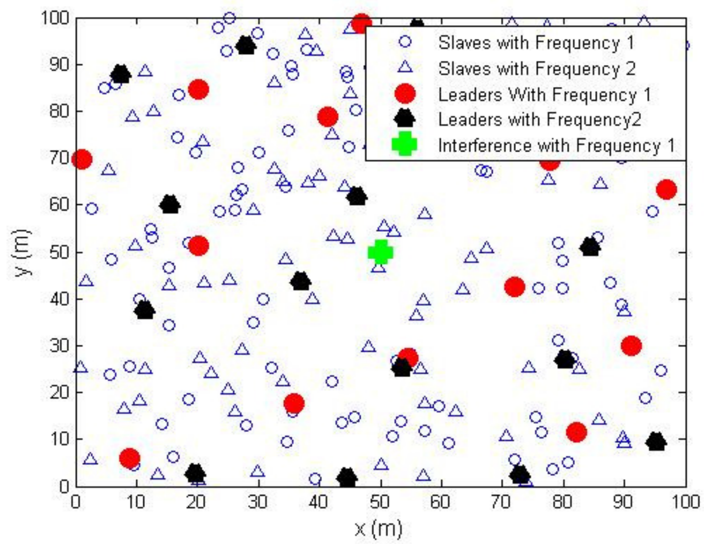
An Example

If there are 200 nodes located within an area of 100 by 100 square meters and frequency band $F = 2$, $\lambda=0.02$, $\alpha= 20$ meters, $\varepsilon=10^{-3}$. Then, $p = 0.0263$, $T_1 = 954$, and $T_2 = 2592$.



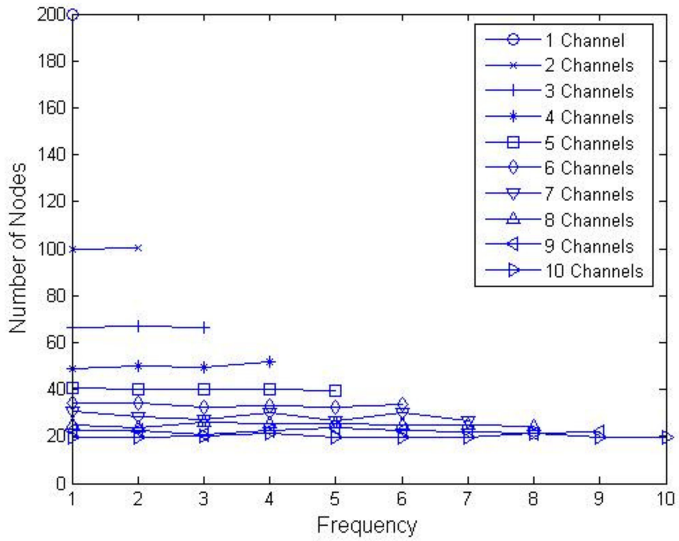
Without Interference



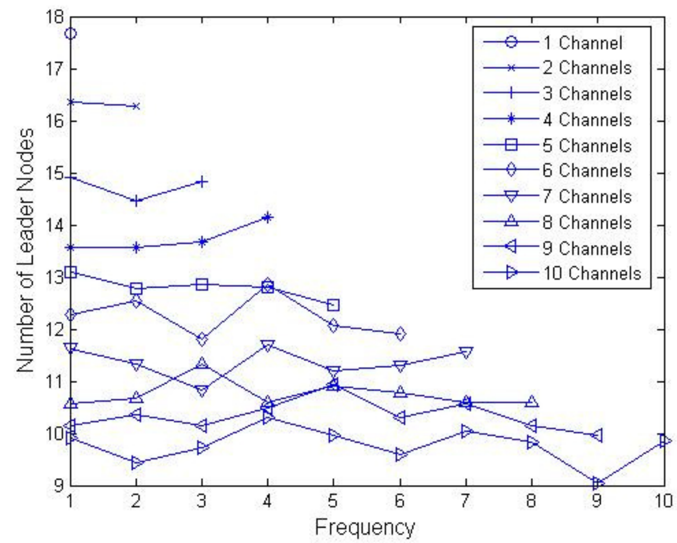
With Interference

An Example-Cont.

Nodes and leader nodes distributed among frequency bands almost equally.



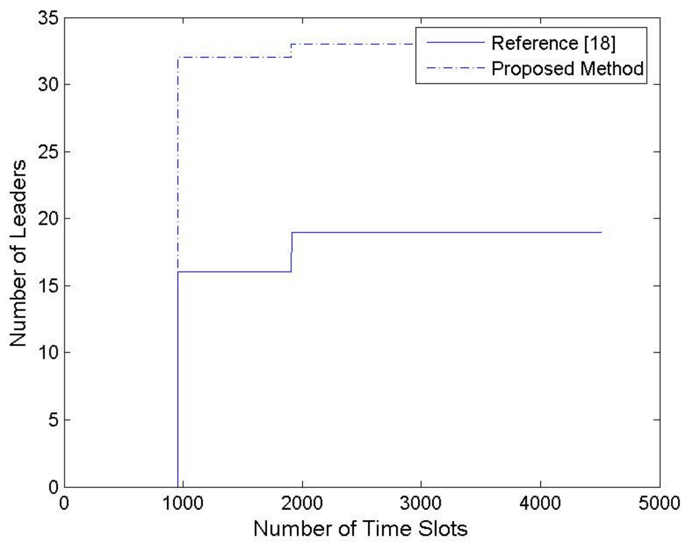
Nodes Distribution



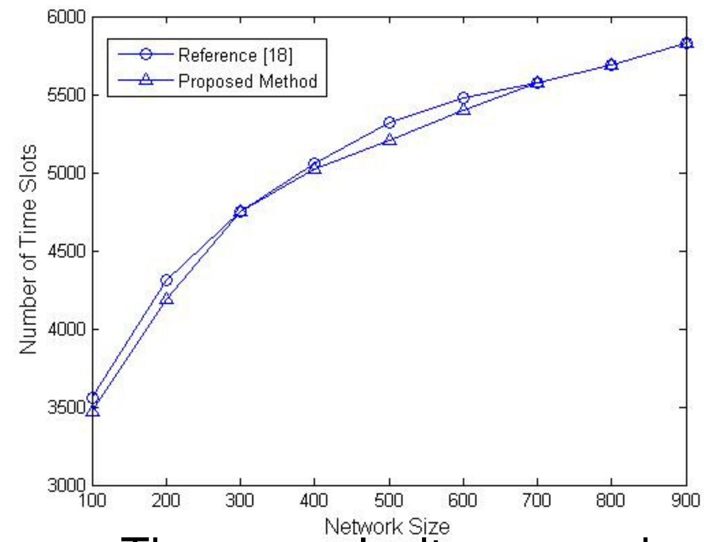
Leader Nodes Distribution

An Example-Cont.

The increase of convergence time and time complexity is not dramatic compared with the reference algorithm.



Convergence comparison



Time complexity comparison

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Summary

- . A synchronization method with frequency channel cognition is proposed to satisfy the multi-hop and multi-channel requirements of SDR based wireless grids.
- The simulation examples show that the proposed method can help form the wireless grid within a limited running time.
- The nodes distribution amongst different frequency channels is almost even.

Thank You!

Questions or Comments?