Remote Ad Hoc Sensor Networks

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Remote Ad Hoc Sensor Networks

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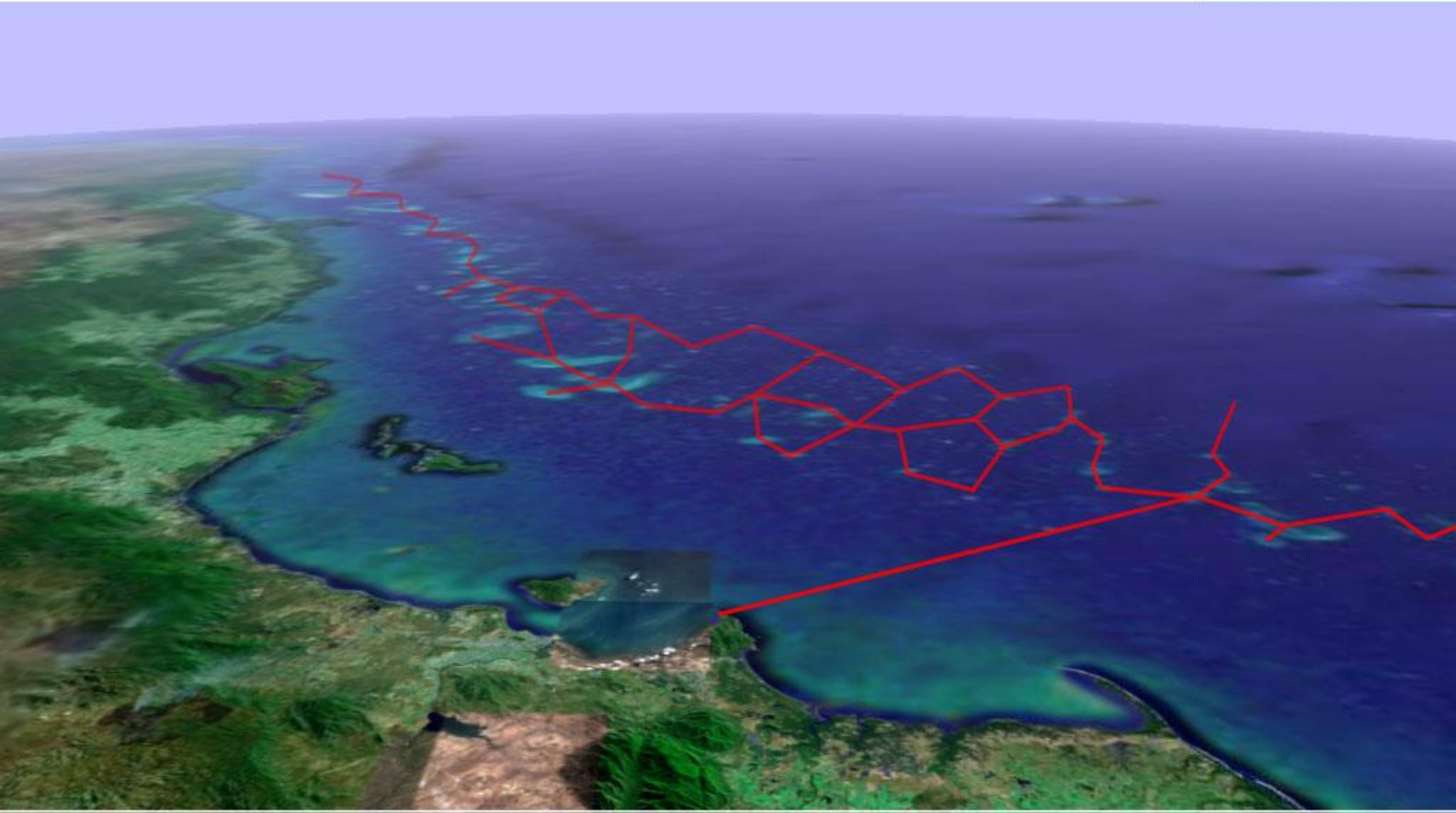

Introduction

Project Overview

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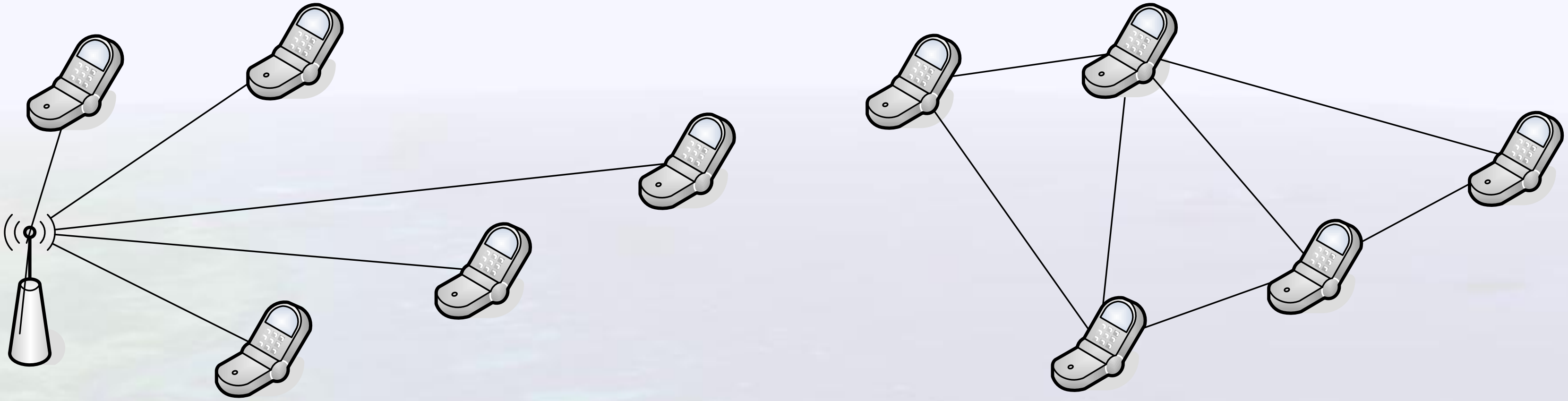
- Australia is a huuuuge country
- Remote and inaccessible locations
- Challenging communication scenarios
- An alternative approach: Ad Hoc Networking

What is an Ad-Hoc Network?



Cellular Network

Ad Hoc Network

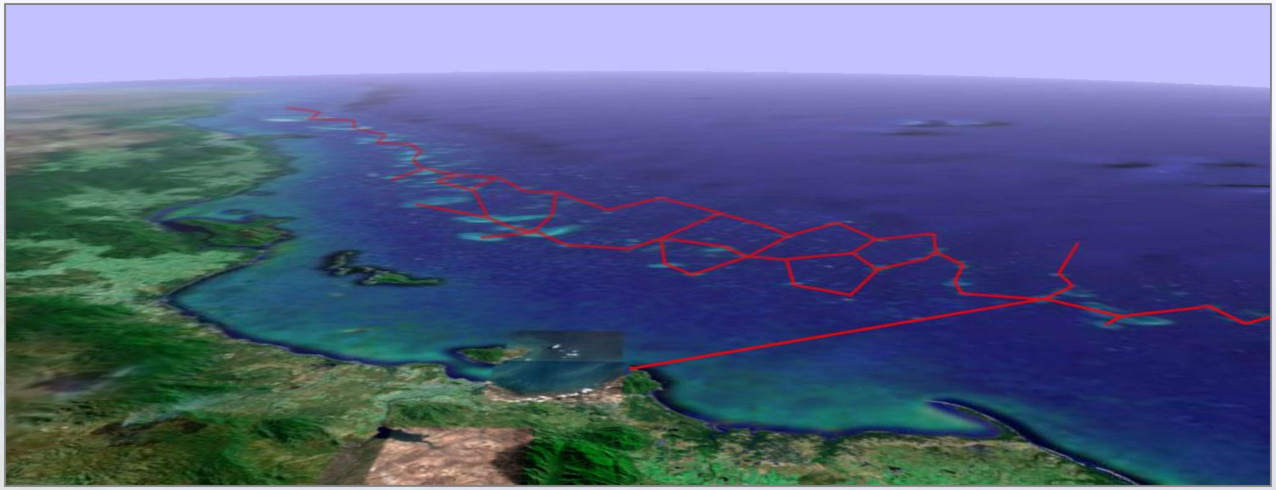
- Peer to peer network
- Distributed infrastructure
- Automatic and adaptive configuration
- Energy efficient

Typical Ad Hoc Sensor Networks

- Network Conditions
  - Dense, well connected topologies
  - Low traffic rates
- Tiny sensor nodes
  - Data collection
  - Data processing
  - Low power radios
- Long battery life

Crossbow "Mica" Motes

Remote Ad Hoc Sensor Networks



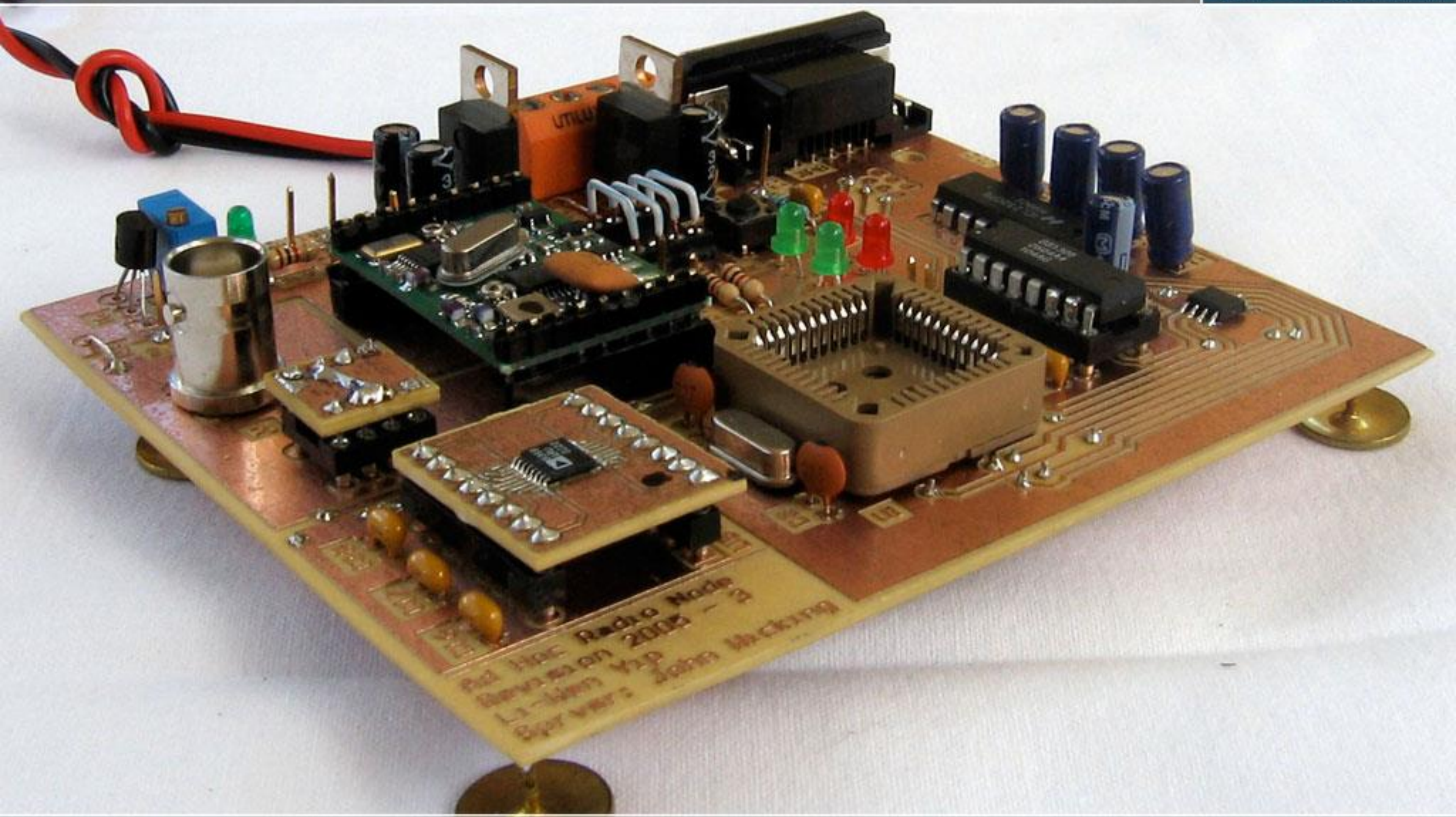
- Size
  - Large geographical areas
  - Remote and inaccessible locations
- Network Conditions
  - Sparse, minimally connected topologies
  - Large link distances (up to 10km)
  - Exposure to environmental conditions

Applications

- Data collection
  - Great Barrier Reef monitoring stations
  - Water trough monitoring on cattle properties
- Rapidly deployable communications
  - Natural disasters
  - Battlefields

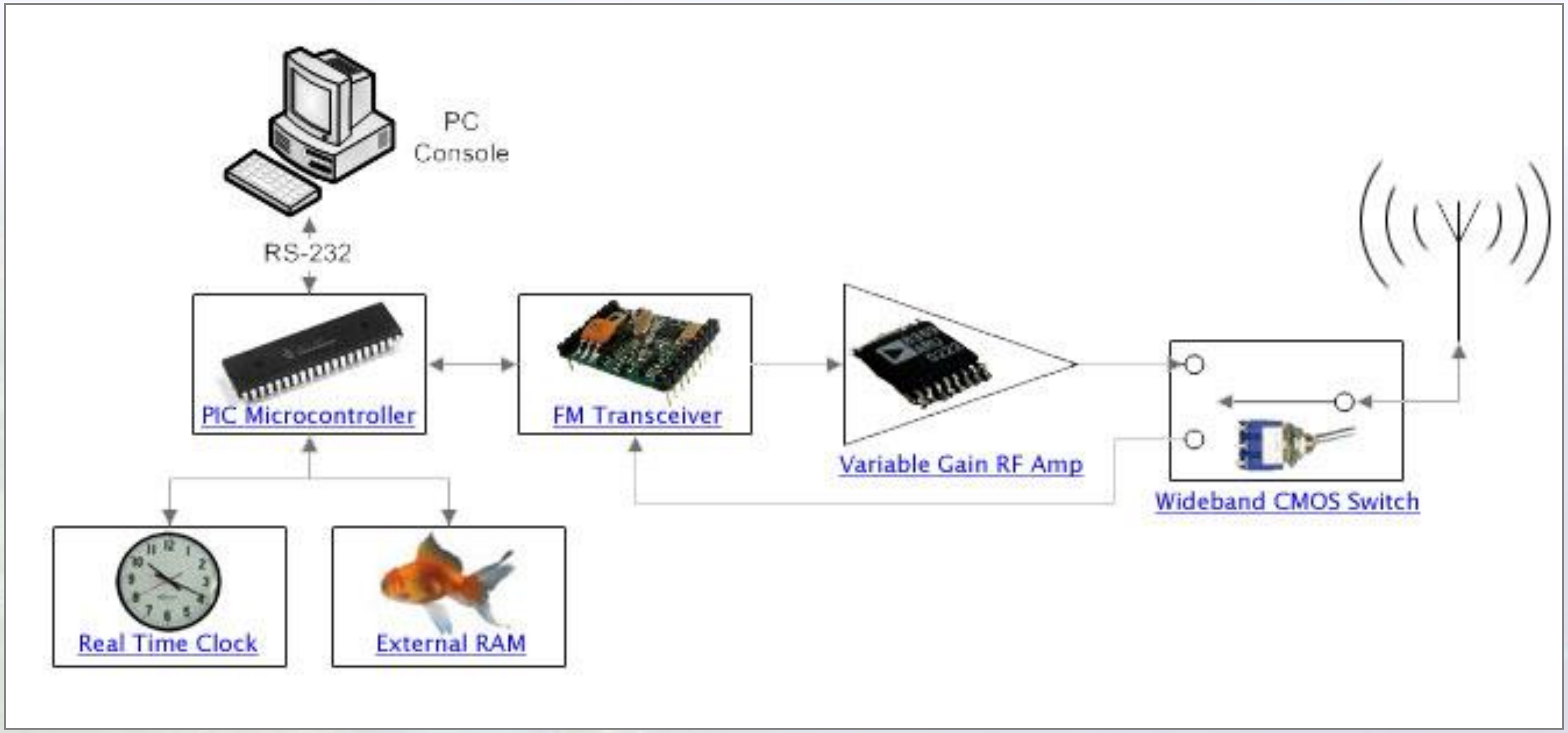
Davies Reef
Remote Weather Station

Remote Ad Hoc Sensor Networks



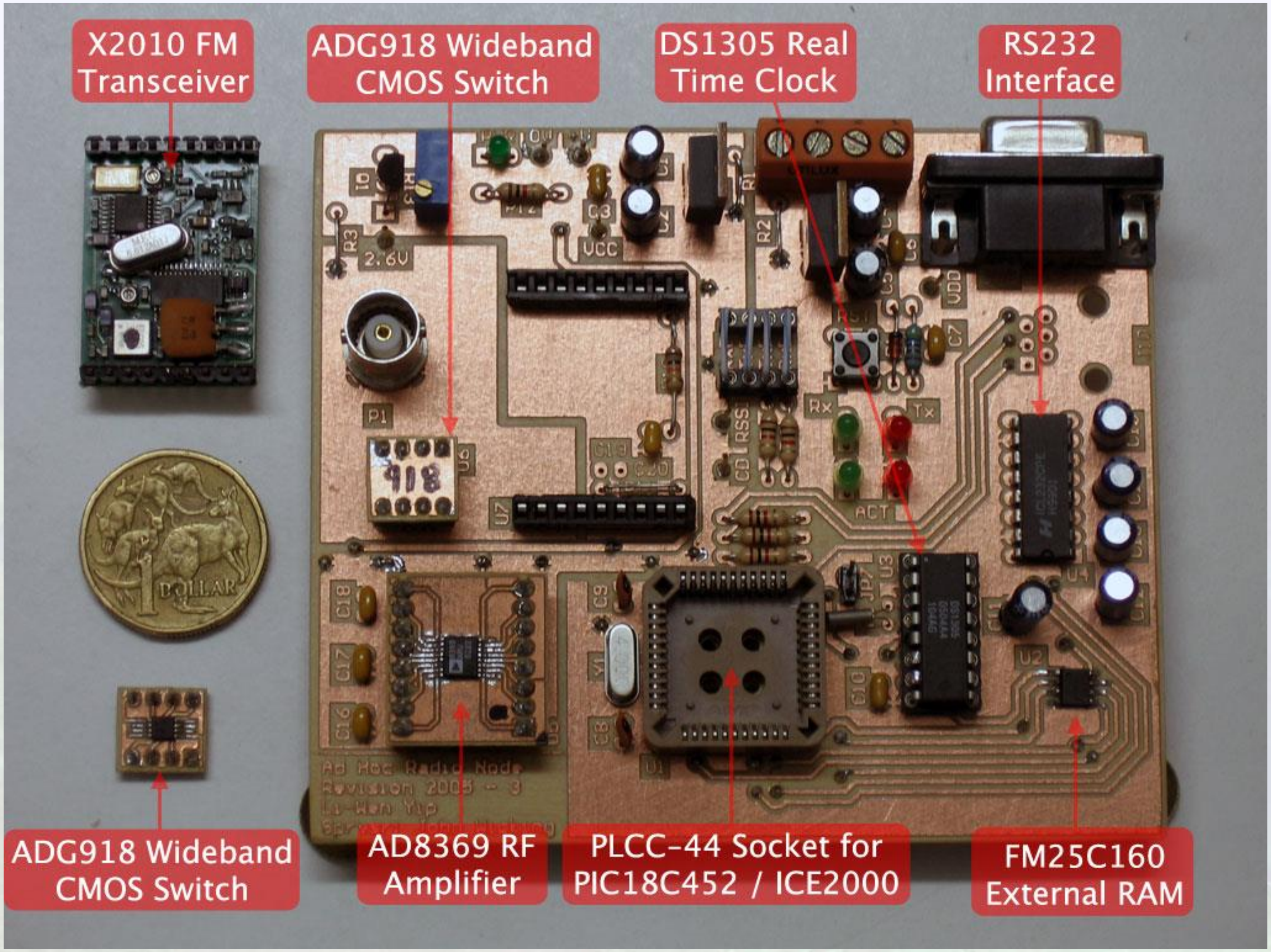
Hardware

Hardware Overview



- Microcontroller based (PIC18C452)
- Programmable output power
- Cache routing information
- Schedule sleep periods
- CMOS Switch only consumes 5µA

Here's one I prepared earlier…



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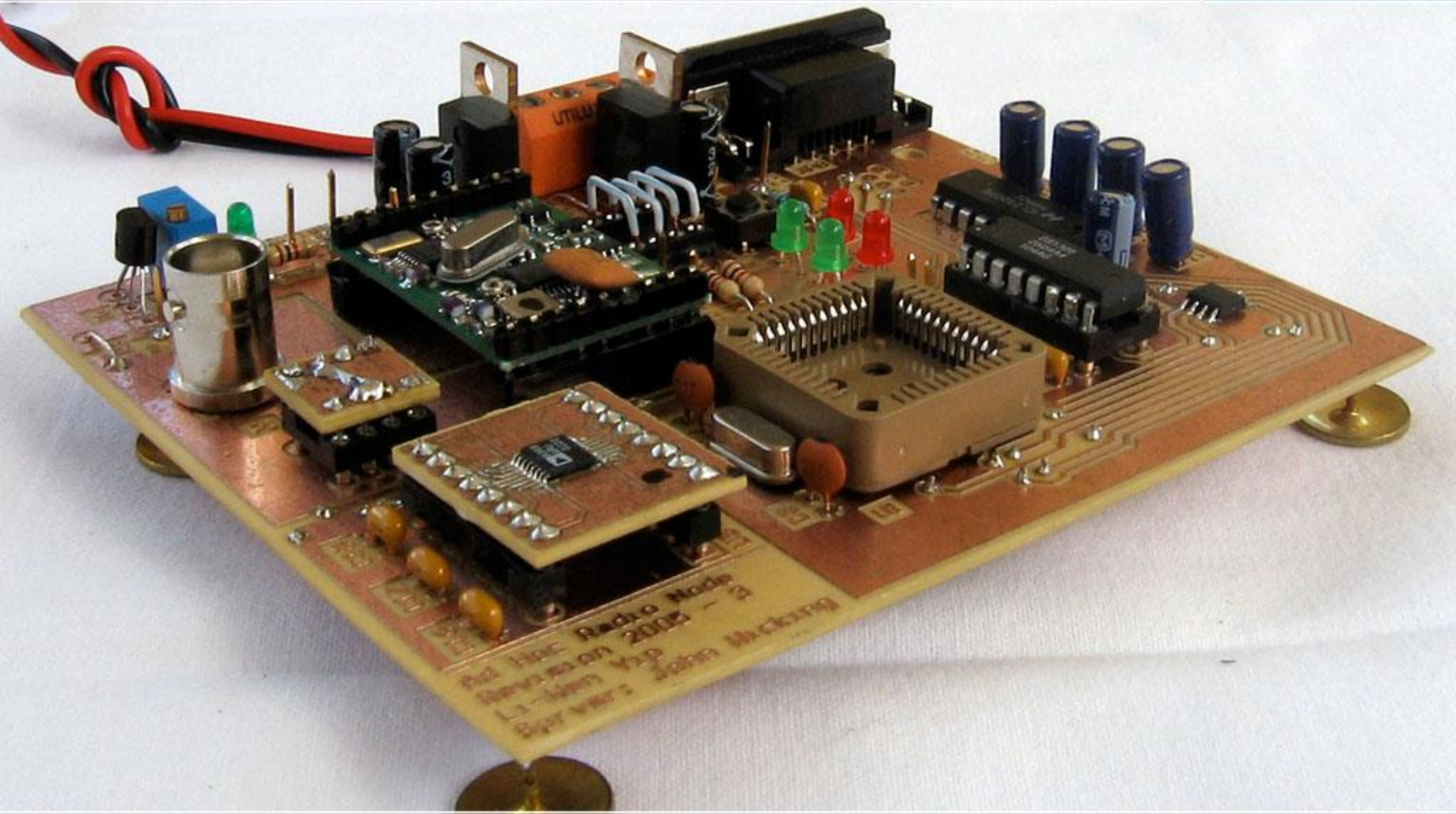
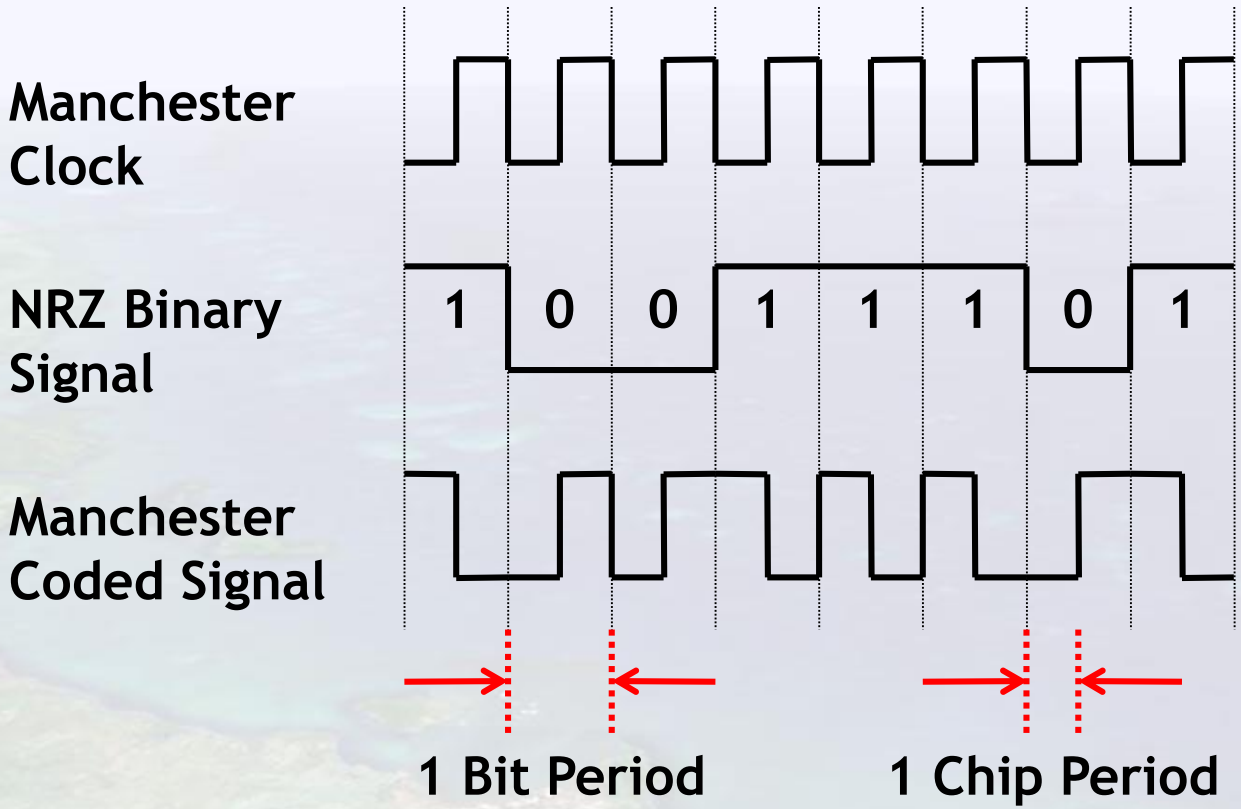


Software

Software

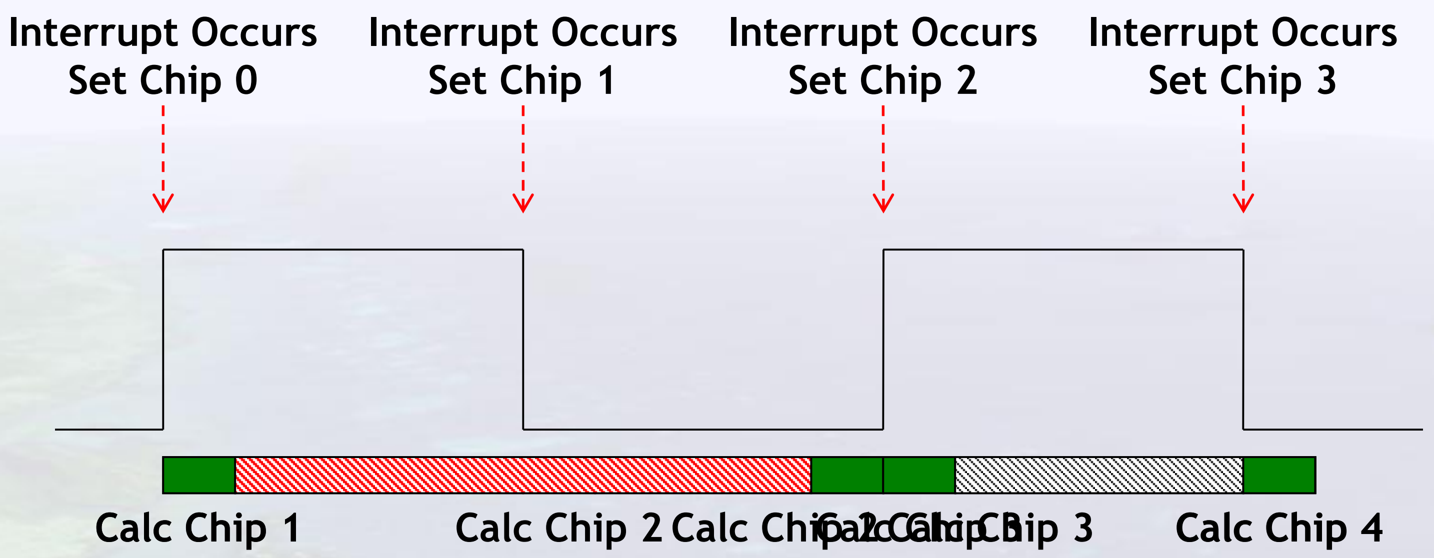
- **Manchester Encoding/Decoding**
- Power Saving Techniques
- Dynamic Address Allocation

Manchester Encoding / Decoding



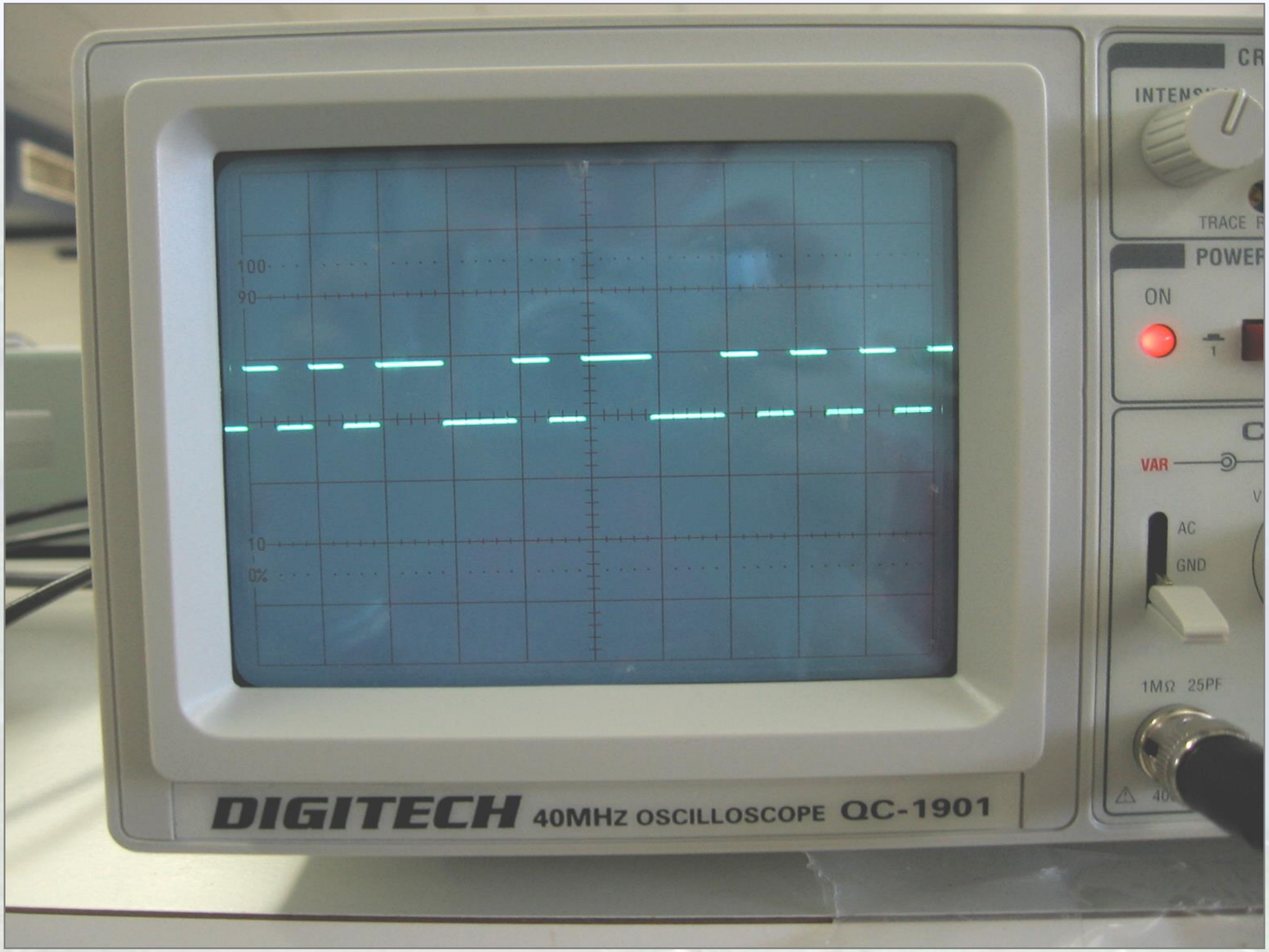
- 1 -> 10; 0 -> 01
- Required for the X2010 FM Transceiver

Manchester Encoding

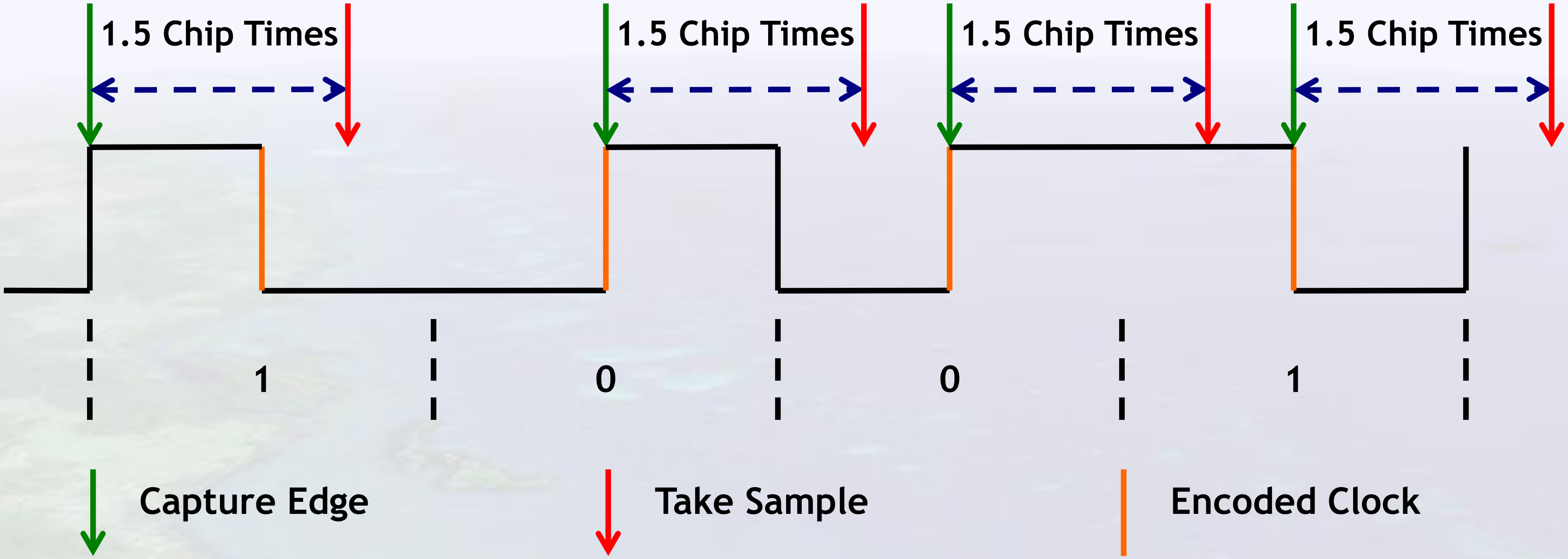


- Each change is calculated in advance and scheduled
- Not dependent on calculation time
- Allows for some slack
- Perform data fetching under interrupt

Manchester Encoding

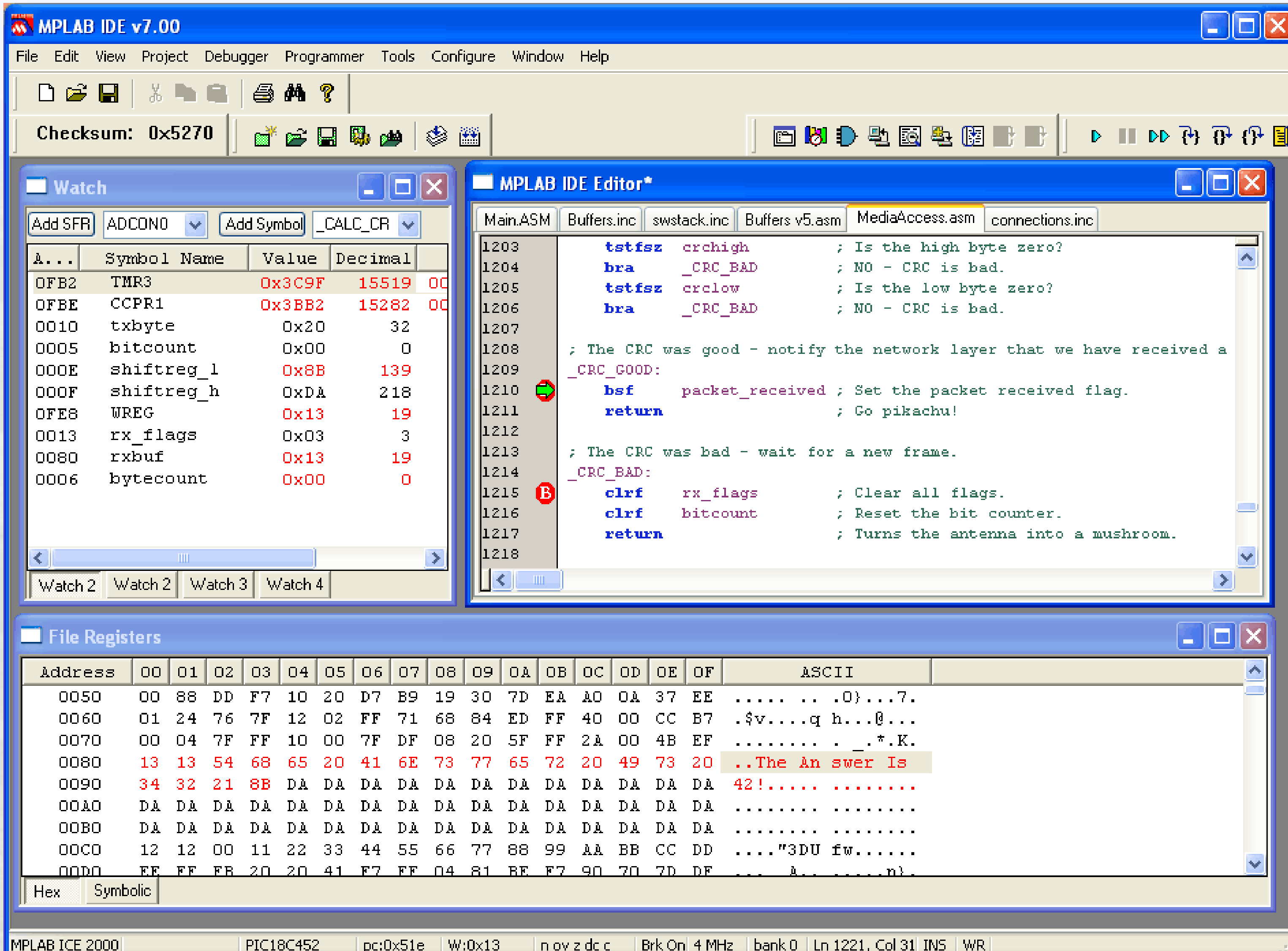


Manchester Decoding

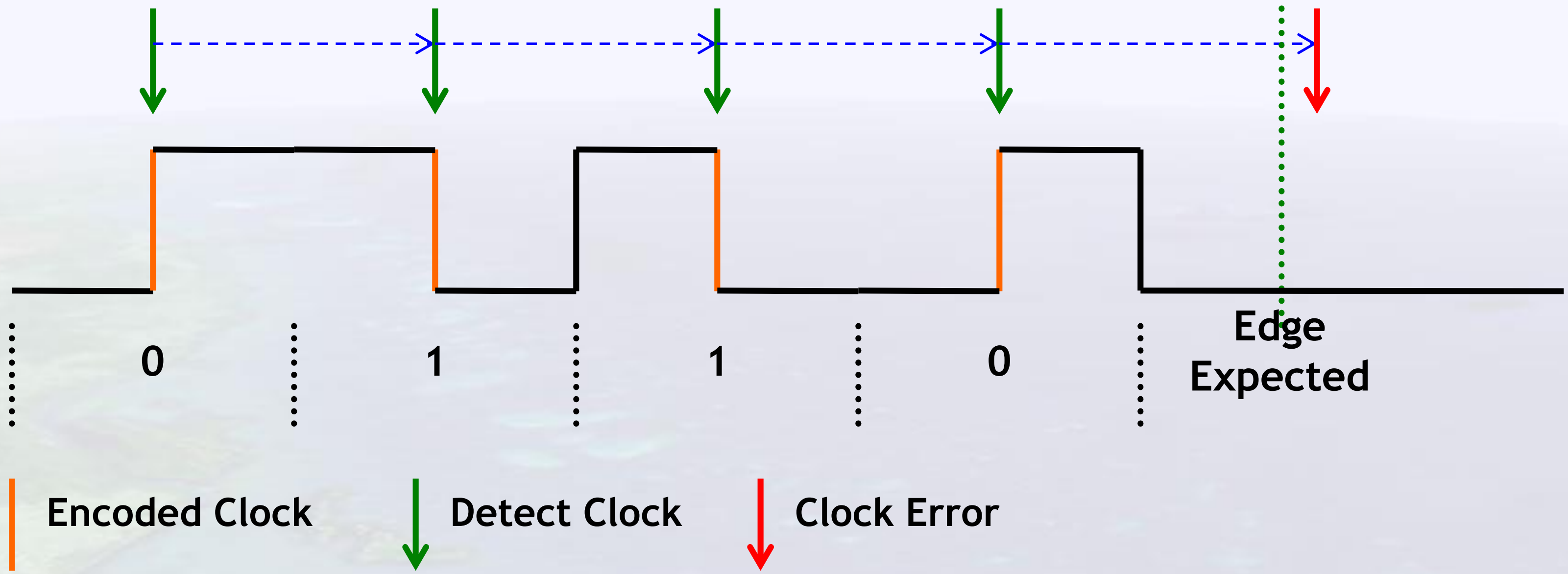


- Previous method involved start and stop bits
- Synchronise to the encoded clock
- Locks as soon as the data bit changes
- Extremely efficient – runs at 9.6 kbps

Manchester Decoding

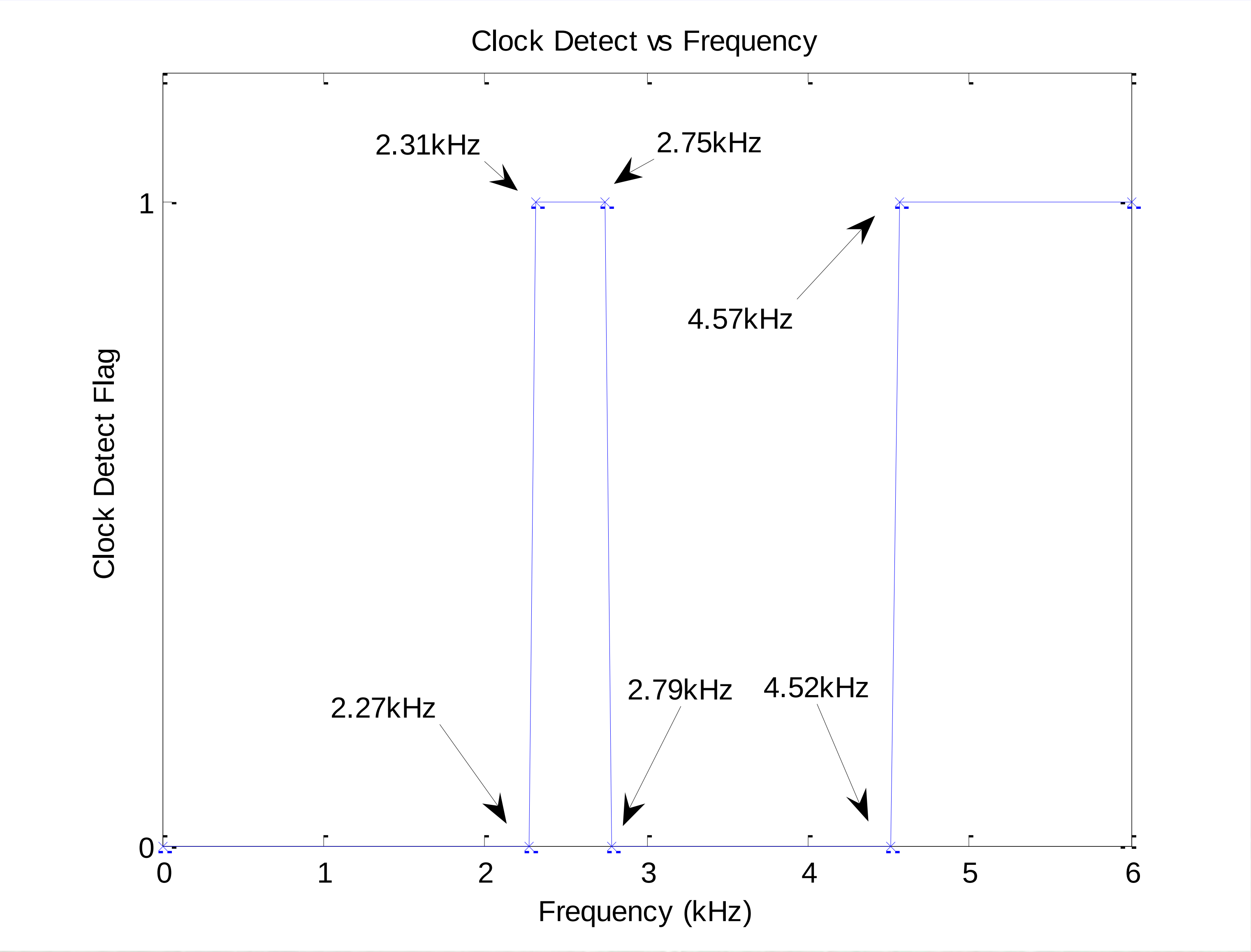


Clock Detection



- Detect if a valid signal is present
- Check that edges occur regularly
- Timer overflows -> clock error

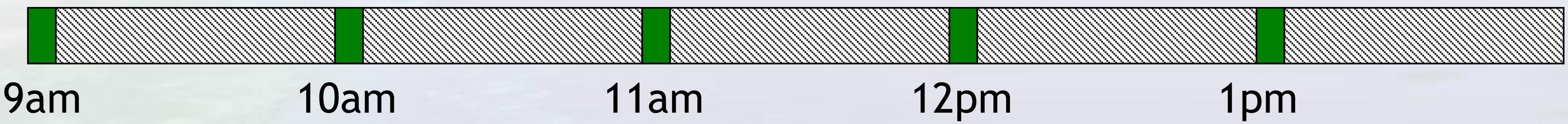
Clock Detection



Software

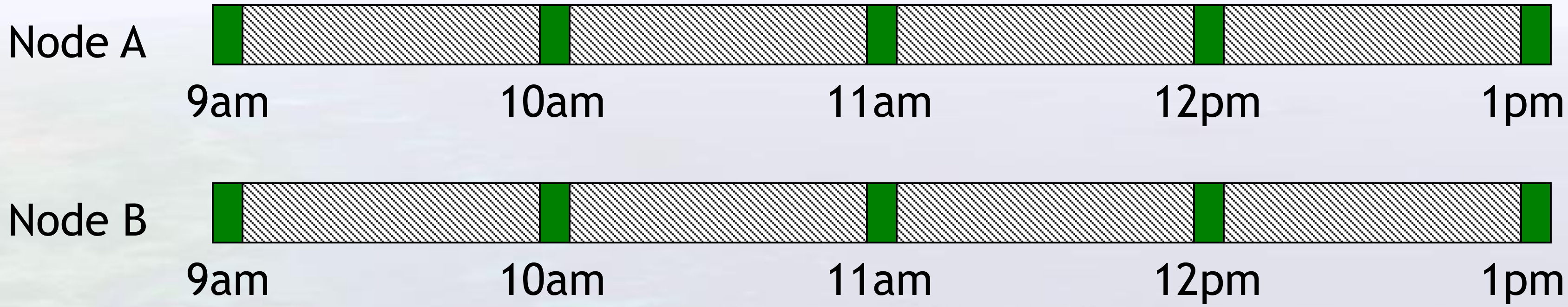
- Manchester Encoding/Decoding
- **Power Saving Techniques**
- Dynamic Address Allocation

Scheduled Rendezvous



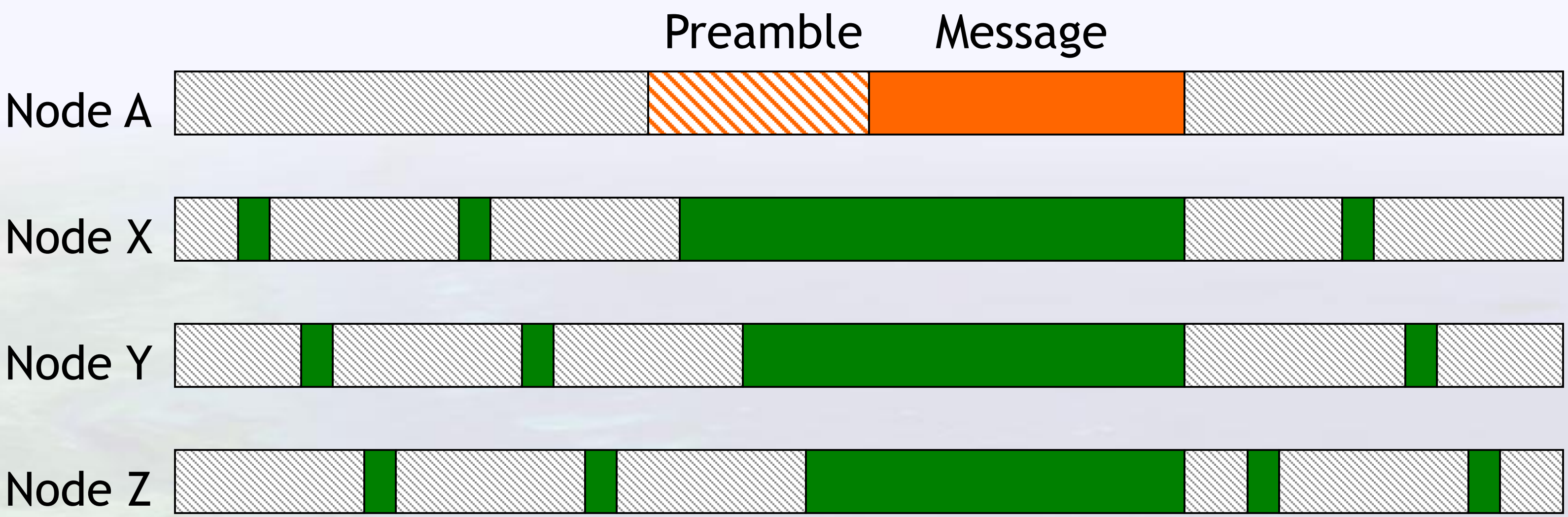
- Nodes are awake for 5 minutes every hour
- Suits periodic bulk data transfer
- Common in data collection applications

Synchronisation



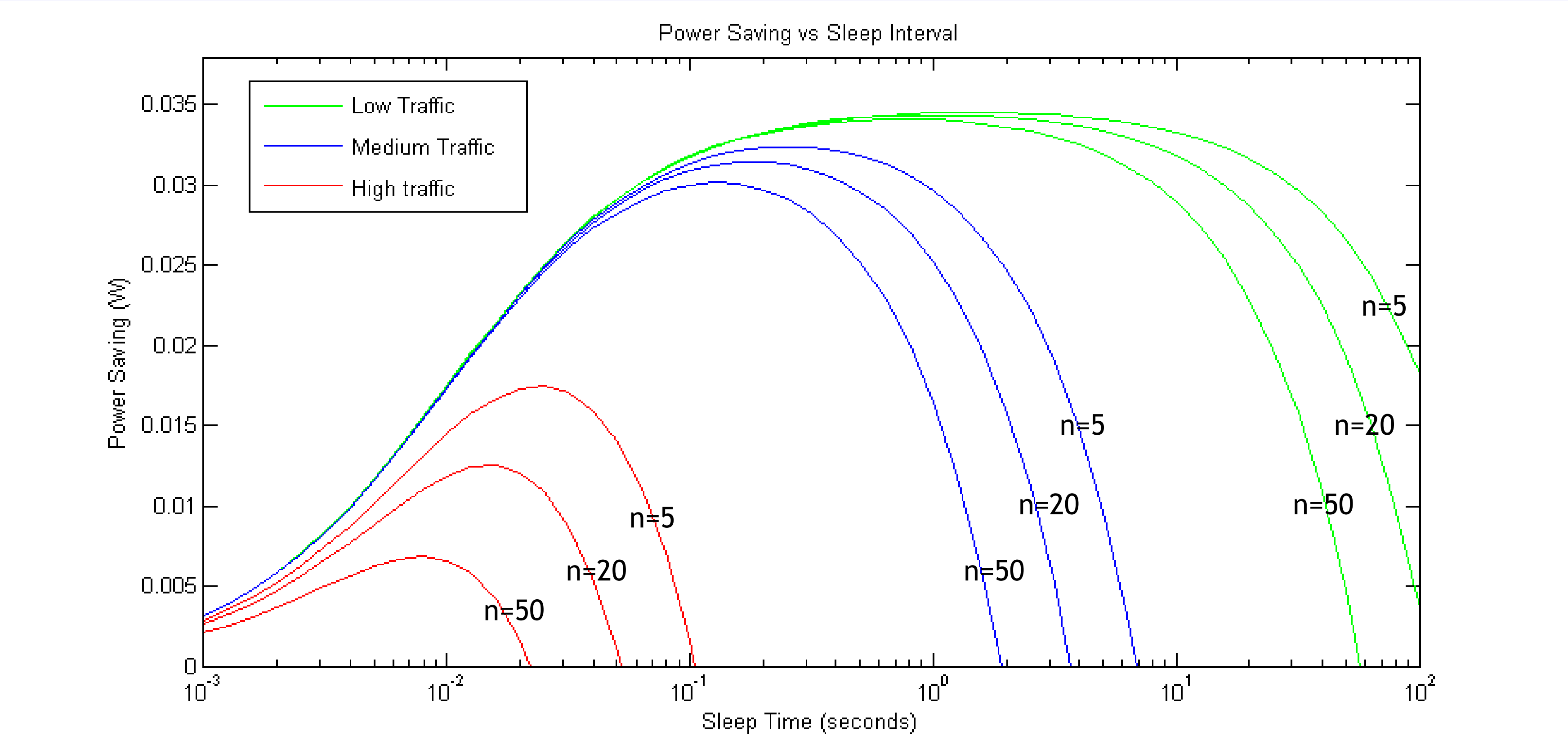
- Distributed synchronisation
  - Large error tolerance
- Clock Drift
  - Phase Detection
- No connectivity between rendezvous periods
  - Preamble sampling

Preamble Sampling



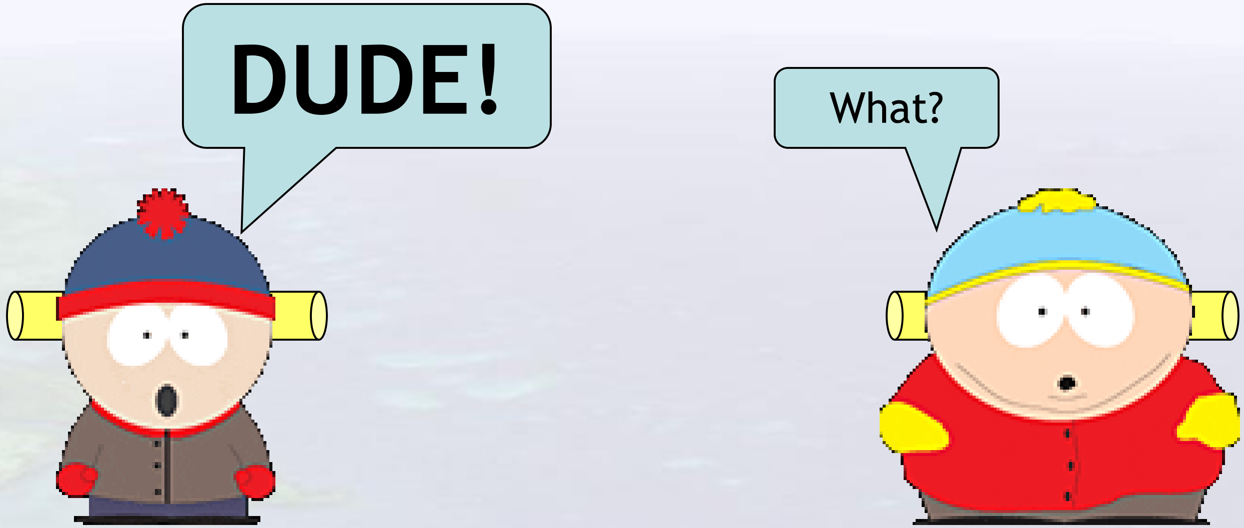
- Use preamble to wake up other nodes
- Frequent brief samples
- Keep listening if there is any activity
- Preamble length = sampling delay
  - Save power while listening
  - Use more power when transmitting

Optimal Sampling Frequency



- Optimum sampling frequency depends on node density and traffic level
- Very effective for low density and low traffic
- Power savings up to 99%

Dynamic Optimisation



- Periods of localised increased traffic levels
- Dynamically adjust the sampling frequency when increased traffic is anticipated
- Reduced chance of collisions

Results

- Scheduled Rendezvous:
  - Scheduling implemented with RTC chip
  - Synchronise two nodes with 1 sec error
- Preamble Sampling:
  - Implemented and verified
  - Maintains connectivity
  - Power consumption proportional to duty cycle
- Dynamic Optimization
  - Basic operation verified
  - Future work – use network and application layer information for more intelligence

Software

- Manchester Encoding/Decoding
- Power Saving Techniques
- **Dynamic Address Allocation**

Dynamic Address Allocation

- Traditional methods are centralised
  - e.g. DHCP Server
- Goals:
  - Dynamically allocate unique addresses
  - Cope with network dynamics
- Three ad hoc addressing techniques:
  - Centralised (elected leader)
  - Decentralised (distributed agreement)
  - **<u>Mutually exclusive address spaces</u>**

Mutually Exclusive Address Spaces

- Every node has a *set* of mutually exclusive addresses
- Every node can give some of its addresses away
- Very low overhead
- New protocol based upon two existing protocols

Here’s how it works:

Address Depletion

I got nothing

Hey everyone, Tom wants some addresses

1

I want some addresses

0

I got nothing

Hey everyone, Tom wants some addresses

1

I'll give you 50 addresses

100

Results

- Partially implemented for ns-2 network simulator
- Didn't work
- Poor documentation and support
- Simulation required to quantify results

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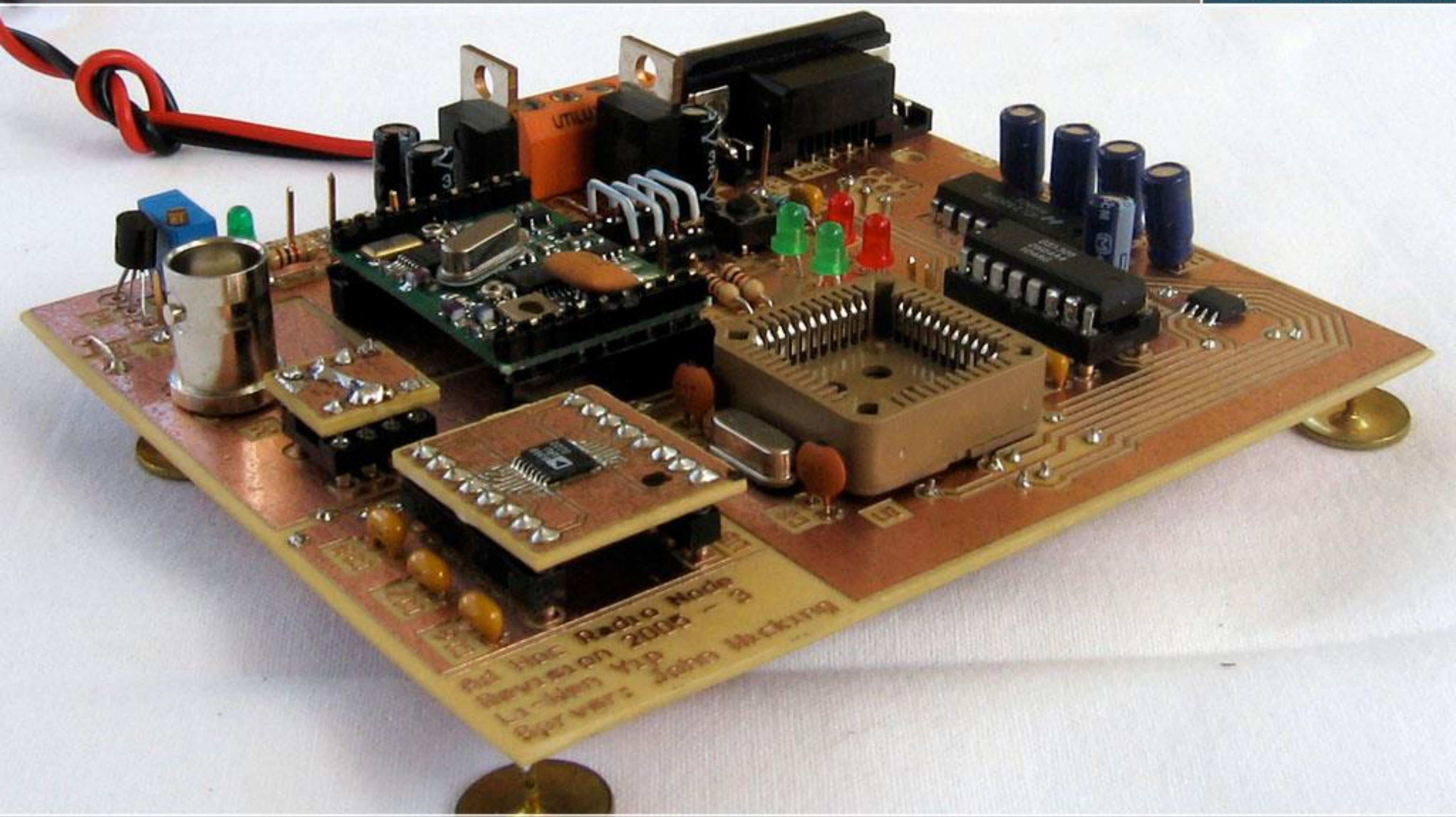

Summary

Summary

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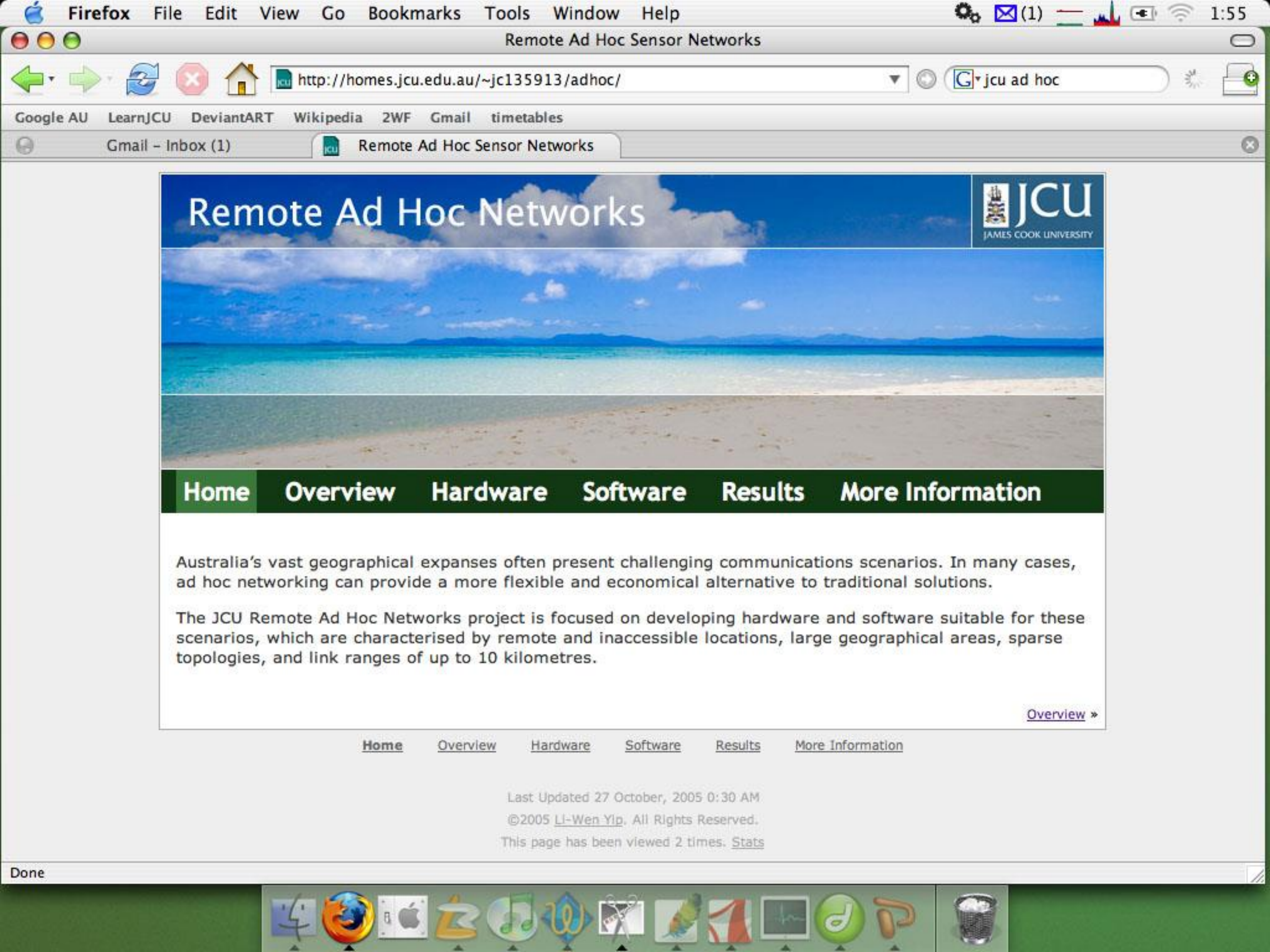
- Hardware improved
  - More compact PCB design
  - Bypass switch – 500mA reduced to 5uA
- Fast, efficient, reliable Manchester codec
  - Fully working mate!
- Power save protocol working
  - Theoretical 99% power saving
  - Requires simulation to quantify results
  - Identified areas for future improvement
- Dynamic address allocation developed
  - Implementation needs to be completed
  - Requires simulation to verify operation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Home Overview Hardware Software Results More Information
Australia's vast geographical expanses often present challenging communications scenarios. In many cases, ad hoc networking can provide a more flexible and economical alternative to traditional solutions.
The JCU Remote Ad Hoc Networks project is focused on developing hardware and software suitable for these scenarios, which are characterised by remote and inaccessible locations, large geographical areas, sparse topologies, and link ranges of up to 10 kilometres.
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