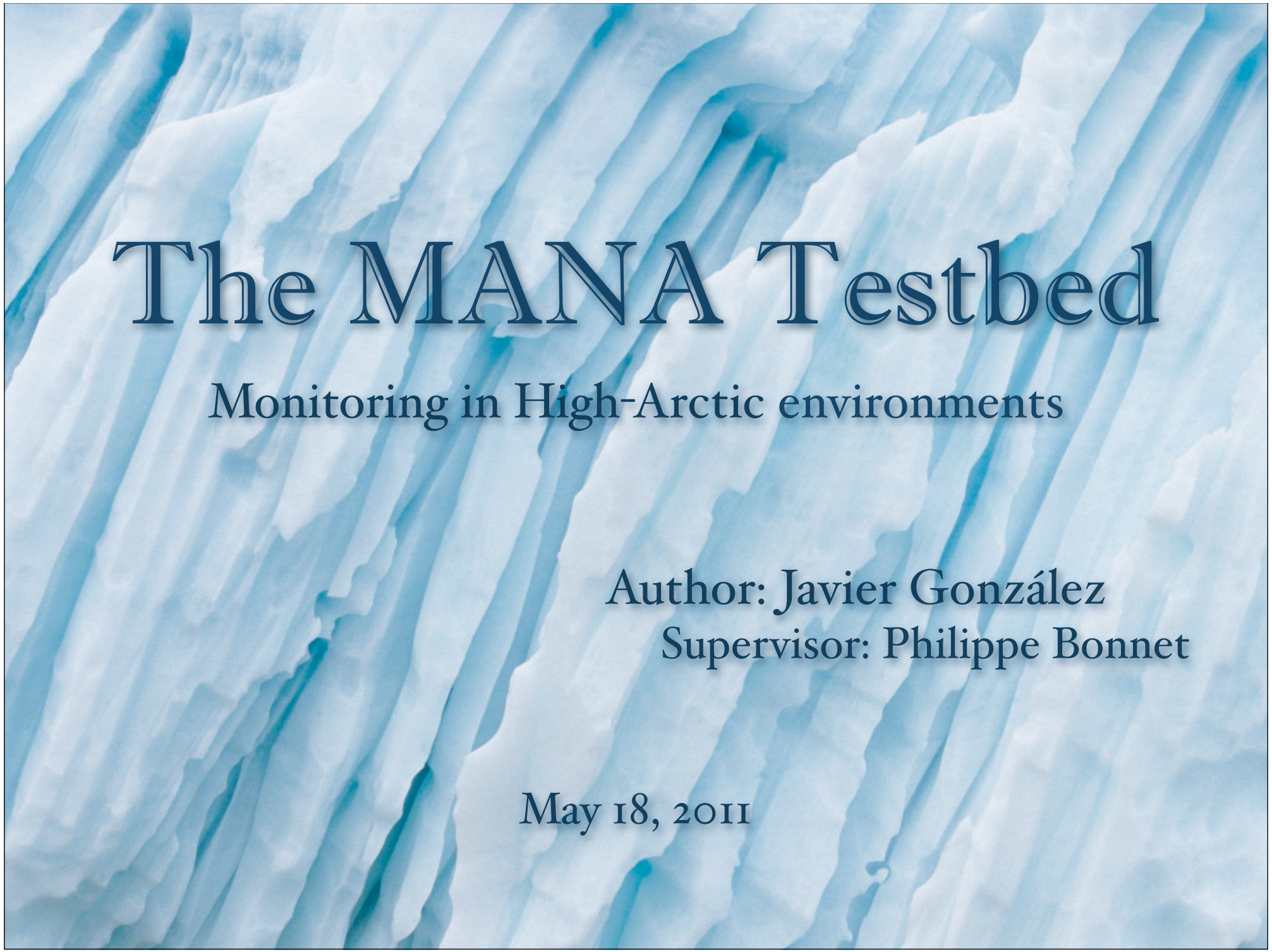
The MANA Testbed
Monitoring in High-Arctic environments
Author: Javier González
Supervisor: Philippe Bonnet
May 18, 2011

Introduction

Context

Problem

Approach

Contribution

Introduction

Context

Problem

Approach

Contribution

Context

Context

- Biologists & Scientists manually measuring in the Zackenberg area
- Water chemistry and freshwater biota
- Difficulties ought to lakes freezing in winter
- Data acquisition ONLY in summer season
- Data did not represent the process in the lakes

Context

- MANA project
- Capoh System monitoring limnic parameters
- Aiming to:
  - Acquire reliable data
  - Automatize the process
  - Adequately describe global behavior in the lakes

Context

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Introduction

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Problem

Approach

Contribution

Problem

Problem

- Research nature of MANA
- The Capoh System MUST evolve and adapt
- Greenland…
  - High costs associated with deployment
  - Unexpected weather conditions
  - Technical and human failures
- Testing???

Problem

Introduction

Context

Problem

Approach

Contribution

Introduction

Context

Problem

Approach

Contribution

Approach

Approach

- Build a Replica inside ITU
- Testbed for new contributions
- Create a maintainable and adaptable system
- Document!
- Contribute!
- Document!!
- Increase value of gathered data

Approach

Introduction

Context

Problem

Approach

Contribution

Introduction

Context

Problem

Approach

Contribution

Contribution

Contribution

- Construction of the Replica
- DAE adaptation to 6LowPAN
- Serial Communication
- Wi-Fi Communication
- Experiments

Contribution

Introduction

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Introduction

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Background

The Capoh Architecture

Microserver

The Capoh Architecture

The Capoh Architecture

The Capoh Buoy

The Capoh Base Station

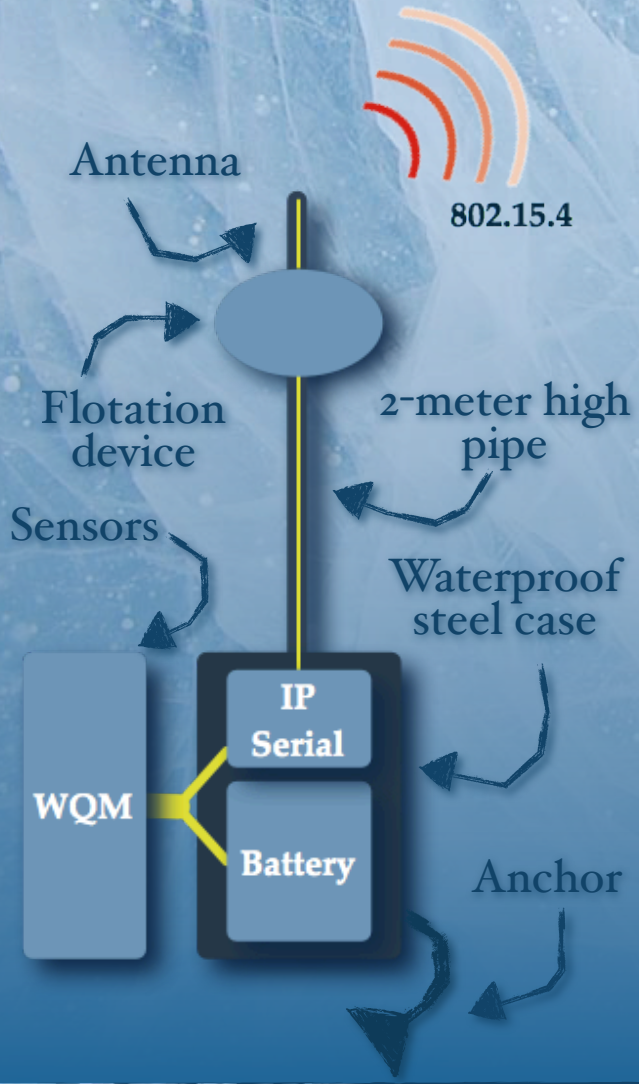
The Capoh Architecture

The Capoh Buoy

The Capoh Base Station

The Capoh Architecture

The Capoh Buoy



- Minimal processing and storage capability
- WET Lab's Water Quality Monitor
- Simple data-logger system. Backup!
- TinyOS. RFSerial

The Capoh Architecture

The Capoh Buoy

The Capoh Base Station

The Capoh Architecture

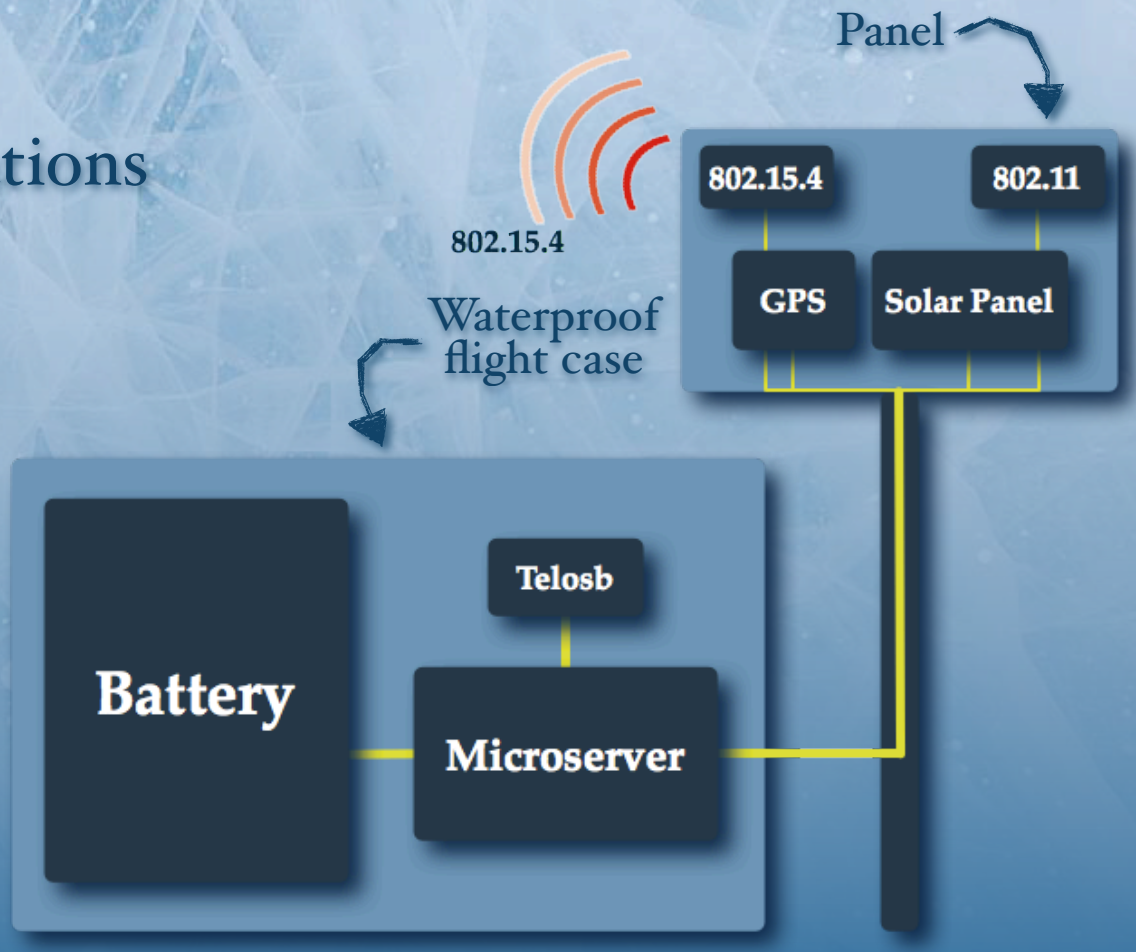
The Capoh Buoy

The Capoh Base Station

The Capoh Architecture

The Capoh Base Station

- Main data processing
- Long-range communications
- Gateway:
  - Recollects
  - Process
  - Stores
  - Sends
- Vexcel MicroServer
  - SBC
  - PCS



The Capoh Architecture

The Capoh Buoy

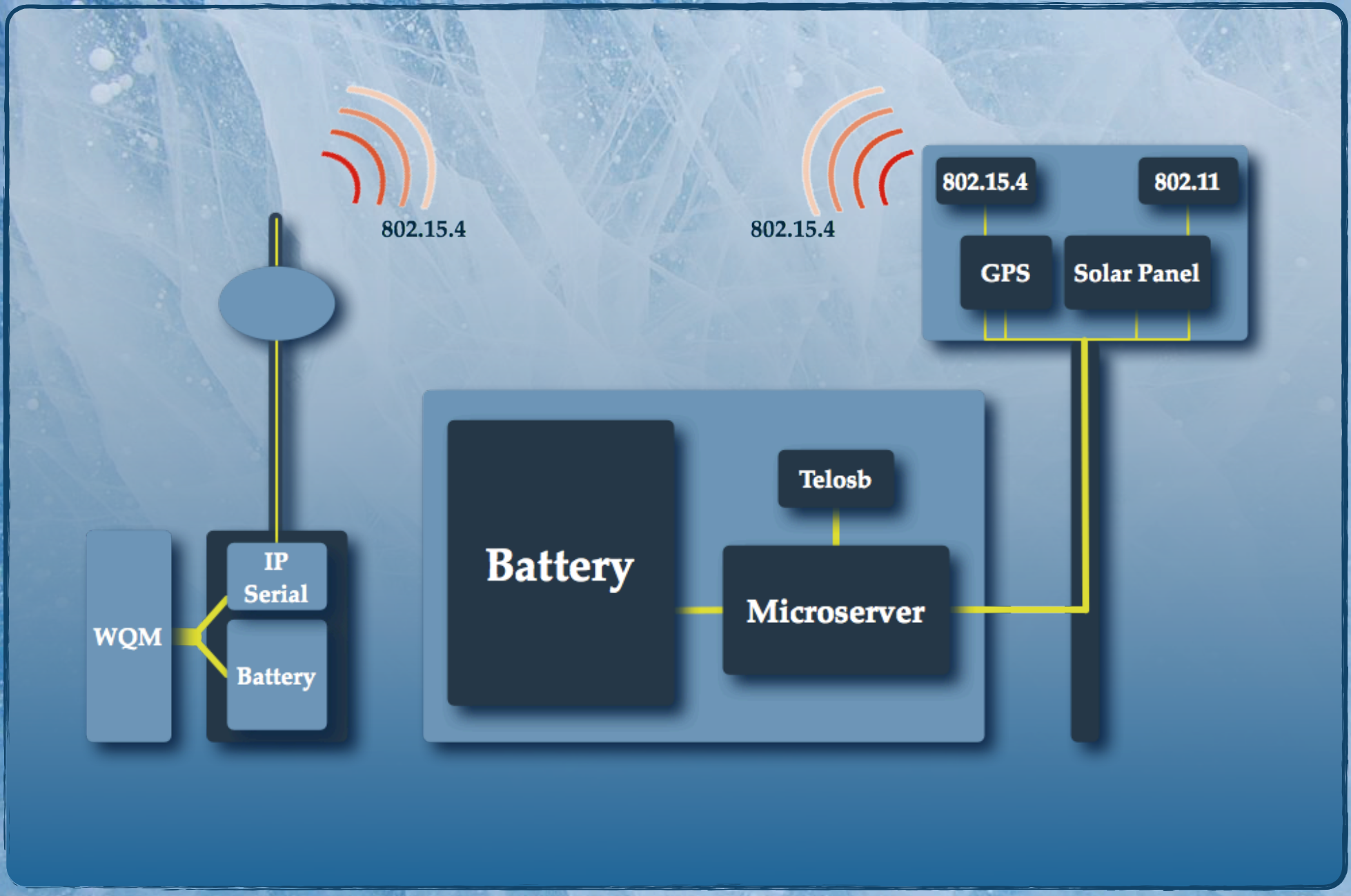
The Capoh Base Station

The Capoh Architecture

The Capoh Buoy

The Capoh Base Station

The Capoh Architecture



Background

The Capoh Architecture

Microserver

Background

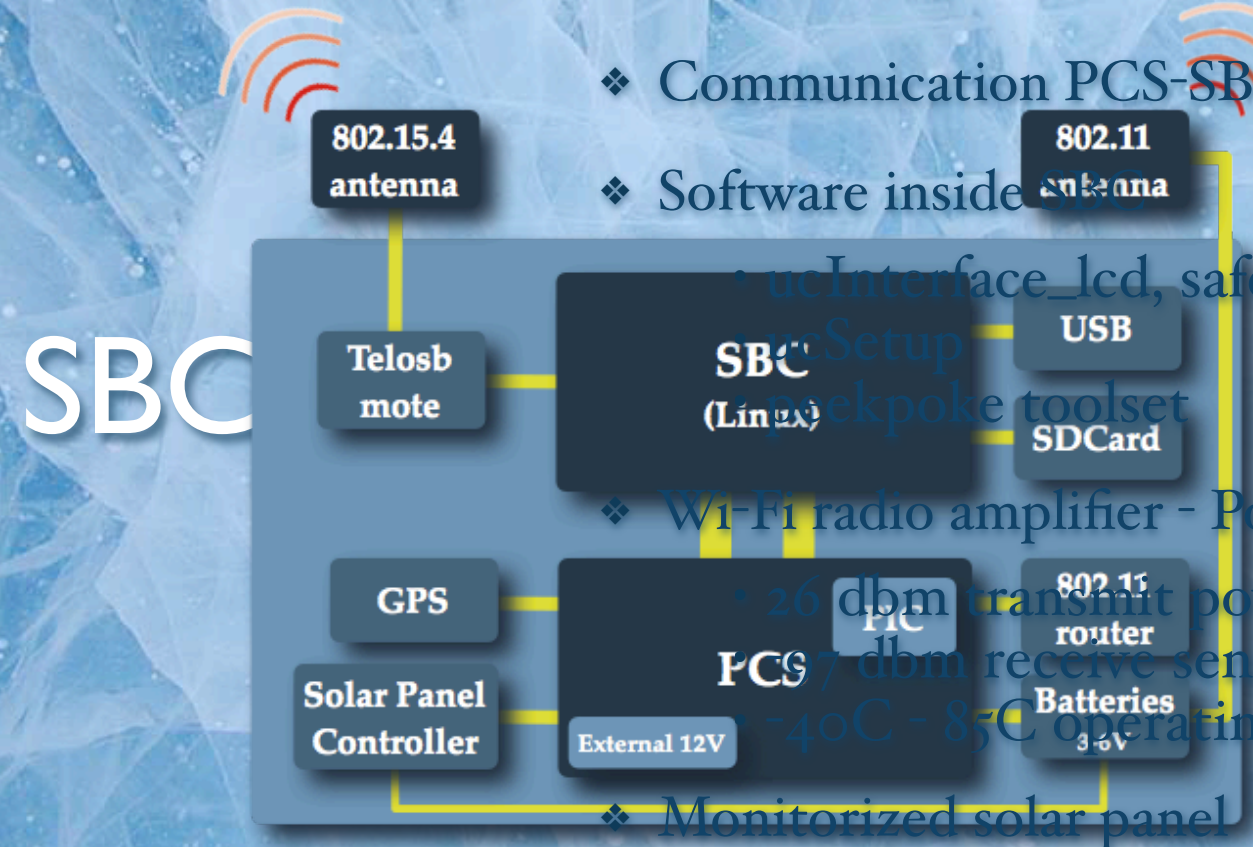
The Capoh Architecture

Microserver

Microserver

Microserver

- Core component of the Capoh Architecture
- Based on Rob Fatland's Vexcel Microserver



- Communication PCS-SBC
- Software inside SBC
  - ucInterface_lcd, safeoff_lcd,...
  - ucSetup
  - peekpoke toolset
- Wi-Fi radio amplifier - PowerStation2
  - 26 dbm transmit power
  - -97 dbm receive sensivity
  - -40C - 85C operating rate
- Monitorized solar panel

Microserver

SBC (TS-7260)

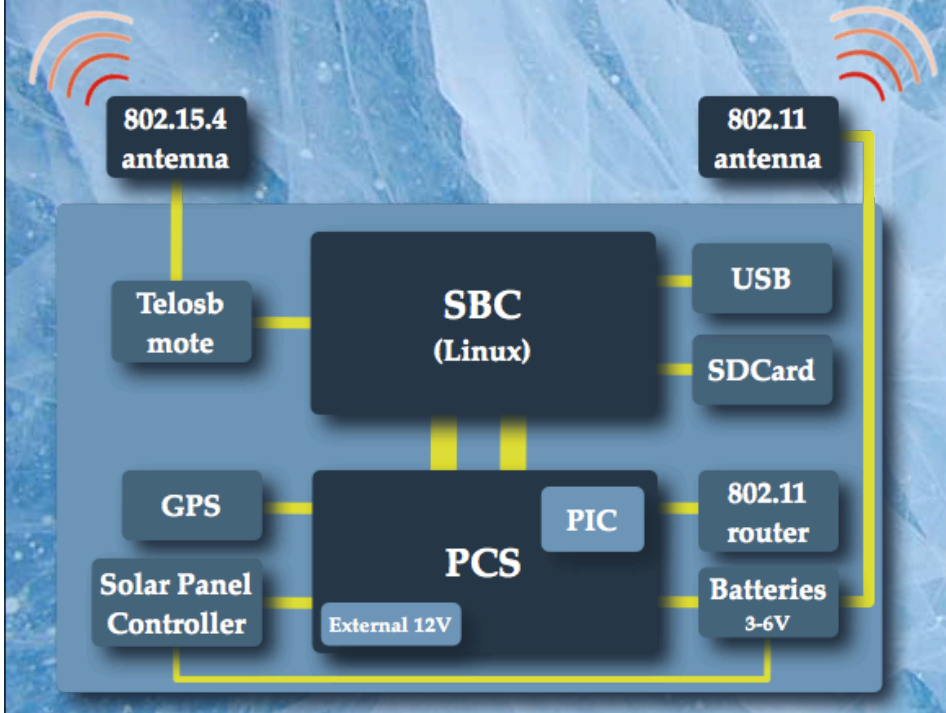
- Linux Debian Lenny (2.6 kernel version)
- Booting from USB and SDCard - *e2fsck*
- Contains all the logic
  - Scripts in the INIT sequence
  - DAE's code
  - Controls PCS's parameters
  - ...

Microserver

PCS

- Controls power consumption
- Bases its operation on *Sleep* and *drop-dead* parameters
- Corner stone of the Microserver
- Direct communication with SBC
- Indispensable!!

Microserver



- Core component
- Synergy between SBC and PCS
- Main contributions

Microserver

Background

The Capoh Architecture

Microserver

Contribution

Replica

Serial Communication

Experiments

Wi-Fi

DAE

Replica

Replica

- First step for testing - Testbed...
- Further contributions
- Document!!

Setting up the system

Code in SBC

Replica

- First step for testing - Testbed...
- Further contributions
- Document!!

Setting up the system

Code in SBC

Replica

Setting up the system

- Use of SBC's ports: (screen, getty, etc)
  - COM ports ttyAM0 & ttyAM1 - jumper JP4
  - T0:23:respawn:/sbin/getty -L ttyAM0 115200 vt100
- Wi-Fi bridge - SSH
- Linux Debian 5 (Lenny) Kernel version 2.6.21
  - exec-c"console=ttyAM0,115200root=/dev sda1secondary=/dev/tssdcarda1init =/sbin/init rootdelay=6"

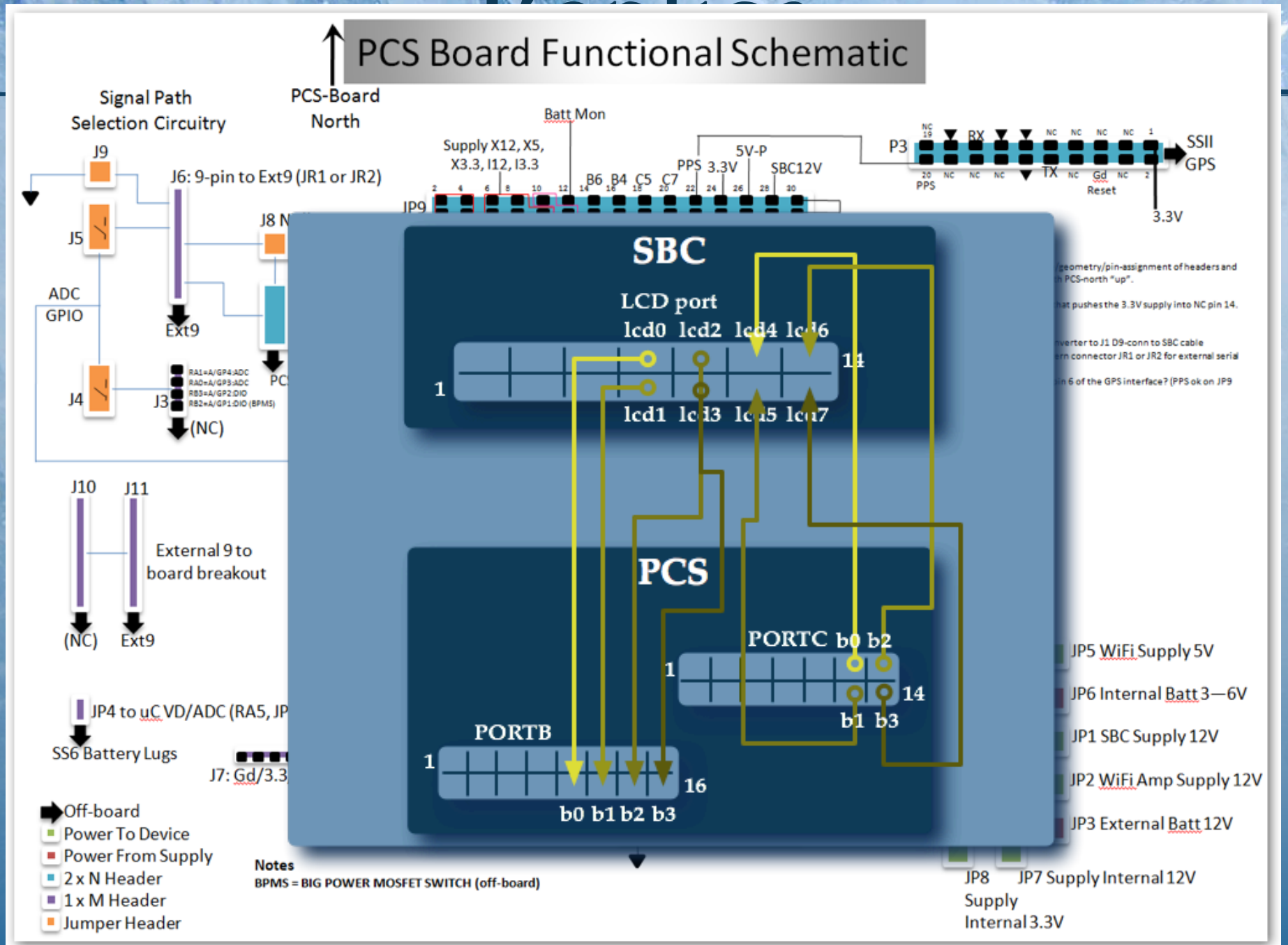
Replica

Setting up the system

- Memory Technology Device (MTD)
- TS-7260 FLASH

Name	FLASH addr	Mem addr	Lenght	Entry Point
(reserved)	0x60000000	0x60000000	0x01D04000	0x00000000
RedBoot	0x01D04000	0x61D04000	0x00040000	0x00000000
ramdisk	0x61D44000	0x00600000	0x000C0000	0x00600000
zImage	0x61DE4000	0x00218000	0x001C4000	0x00218000
FIS directory	0x61FFC000	0x61FFC000	0x00003000	0x00000000
RedBoot config	0x61FFF000	0x61FFF000	0x00001000	0x00000000

PCS Board Functional Schematic



Replica

Code in the SBC

- Software plays a big role in the Capoh Architecture
- ARM architecture - cross-compiler
- Different paradigms and context change
  - High level applications - DAE
  - Communication SBC - PCS
  - INIT sequence - *scripts*

Replica

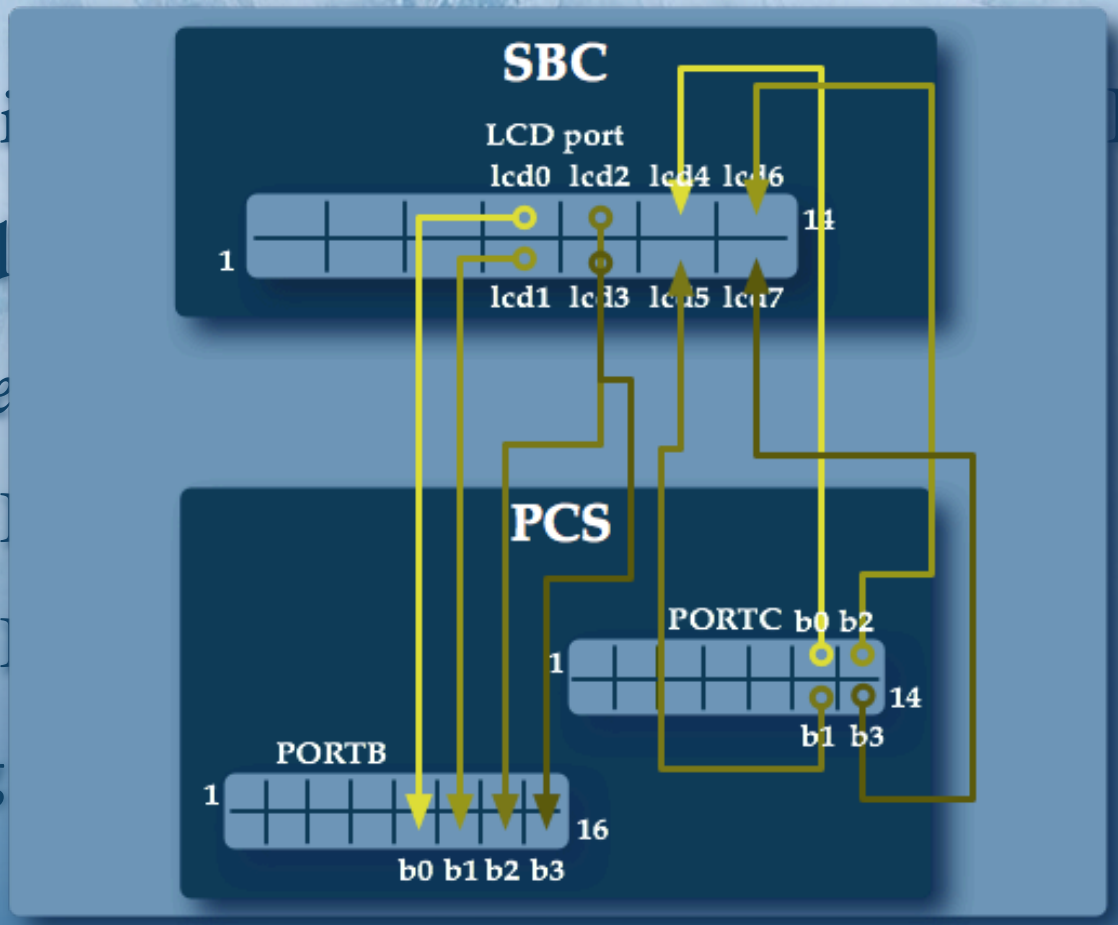
Code in the SBC

- Code Sourcery G++ cross-compiler for ARM
- Install old Linux version - Libraries
- Match specific architecture (TS-7260)
  - -host=/opt/arm-2010q1/bin/arm-none-linux-gnueabi-g++
  - -march=armv4 -mtune=arm9tdmi -g -Wall
- Manually link old/new libraries

Replica

Code in the SBC

- Communi BC
- Layered d
- *ucInterface*
  - Query
  - Query
  - Setting



Replica

Code in the SBC

- *MicroController.cpp*
  - High-level interface for *ucInterface_lcd*
  - Additional level of abstraction - modularization
- *ucSetup.cpp*
  - Establishes sleeping and drop-dead periods
  - Corner stone of PCS-SBC's synergy
  - Uses *Log.cpp* - complete and useful log files
- *safeoff_lcd.cpp*

Replica

Code in the SBC

- Scripts in the INIT sequence - Tool Set
- *sbc-setup.sh - sbc-celanup.sh*
  - Set drop-dead and sleeping periods for *ucSetup*
  - Turns on Wi-Fi amplifier
  - Turns solar panel up and down
  - Sets RTC and runs GPS
  - Triggers the DAE
  - Shutdowns Linux gracefully - PCS signal

Replica

Code in the SBC

- *usb-setup.sh - usb-cleanup.sh*
  - Updates and prepares usb log files for later use
- *startip-driver.py & controlip-driver.py*
  - Starts ip-driver
  - Creates a file descriptor - input & output
  - Controls DAE's operation

Replica

Contribution

Replica

Serial Communication

Experiments

Wi-Fi

DAE

Contribution

Replica

Serial Communication

Experiments

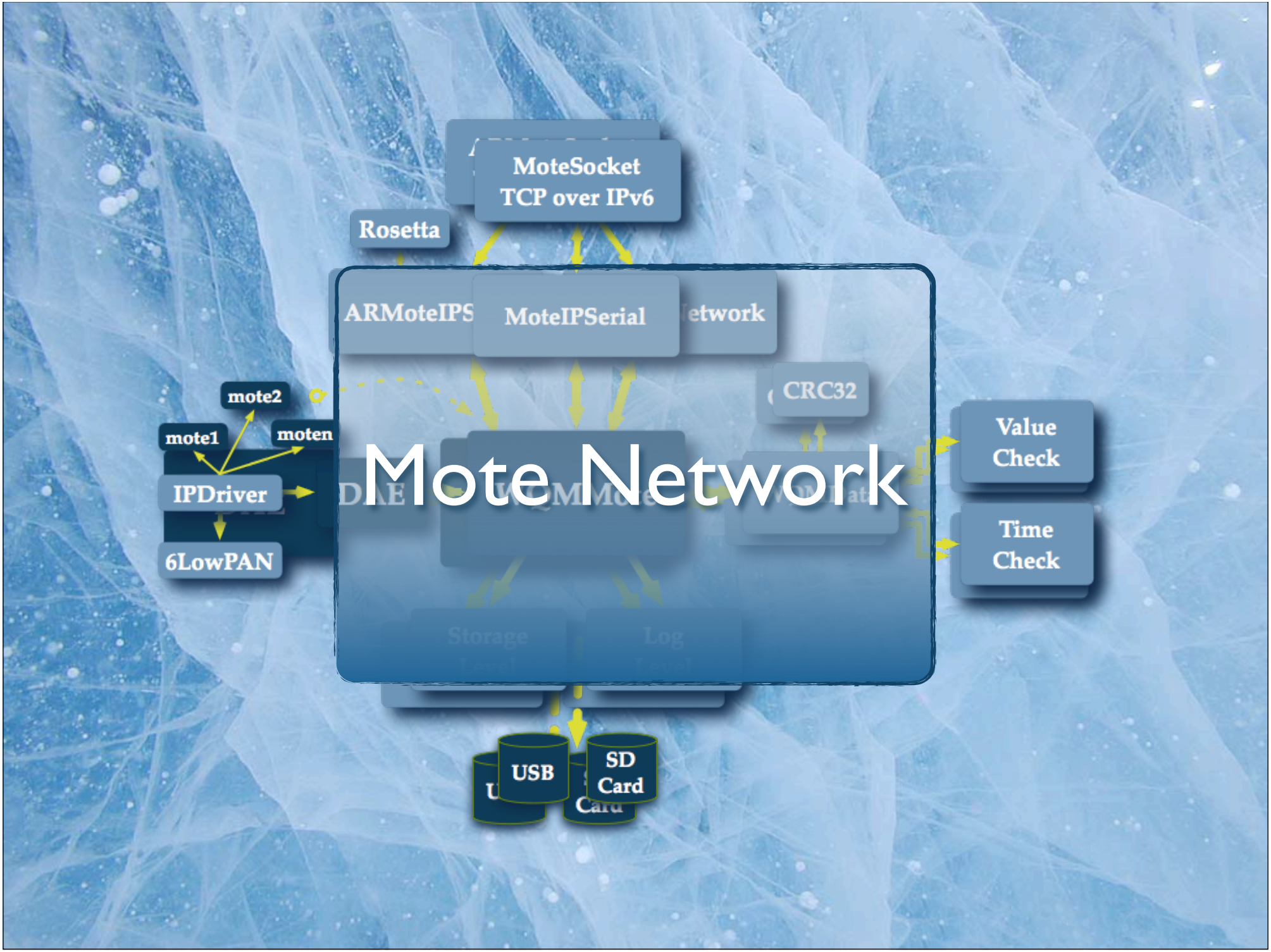
Wi-Fi

DAE

DAE

DAE

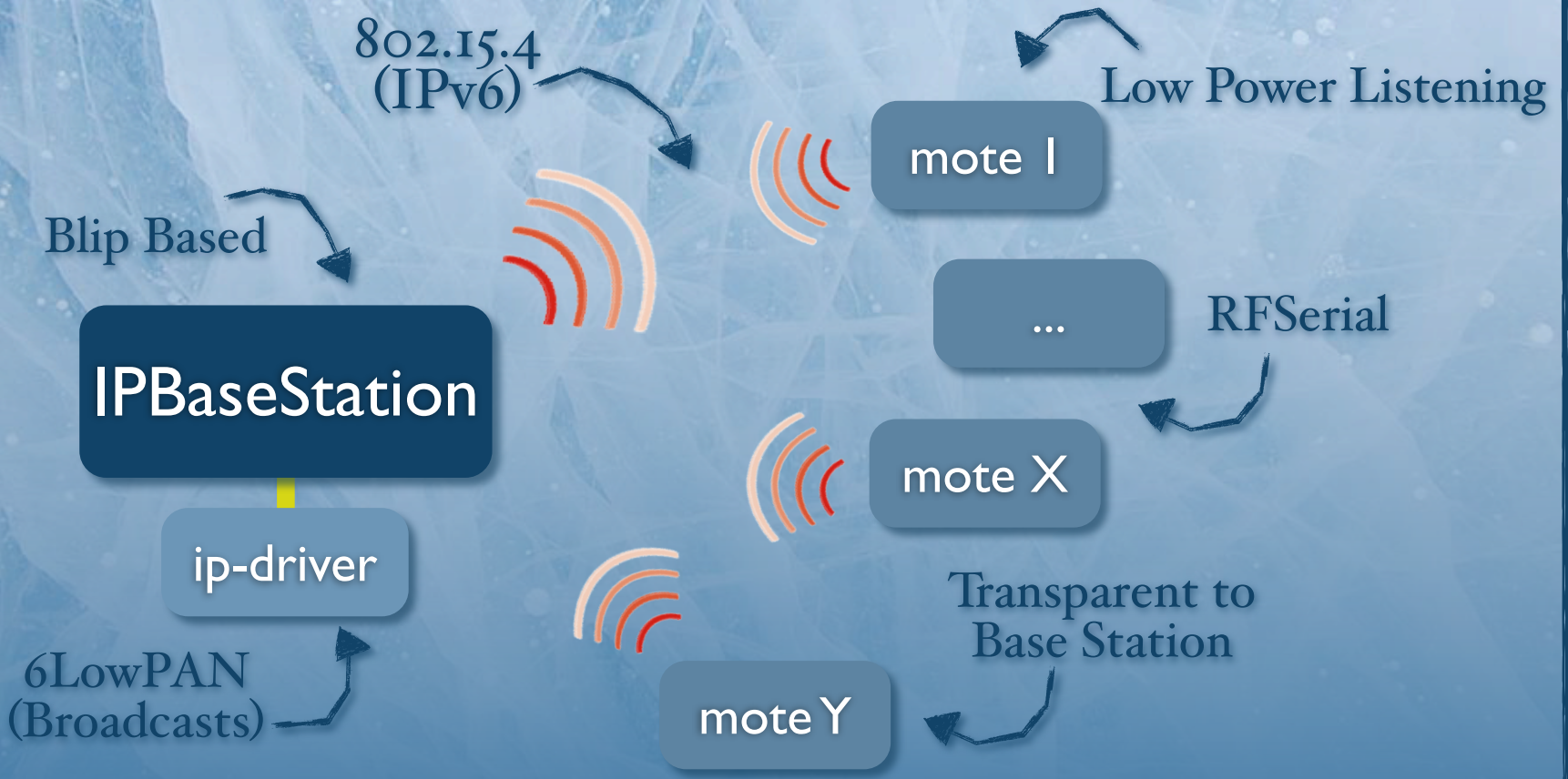
- From Rosetta (Arch Rock) to 6LowPAN
- 802.15.4 under TinyOS 2.x
- From IPv4 to IPv6
- Layered design:
  - Interfaces
  - Contracts
  - Modularization


MoteSocket
TCP over IPv6
Rosetta
ARMoteIPS
MoteIPSerial
etwork
CRC32
mote2
mote1
moten
IPDriver
6LowPAN
Mote Network
Value
Check
Time
Check
Storage
Log
USB
SD
Card

Mote Network

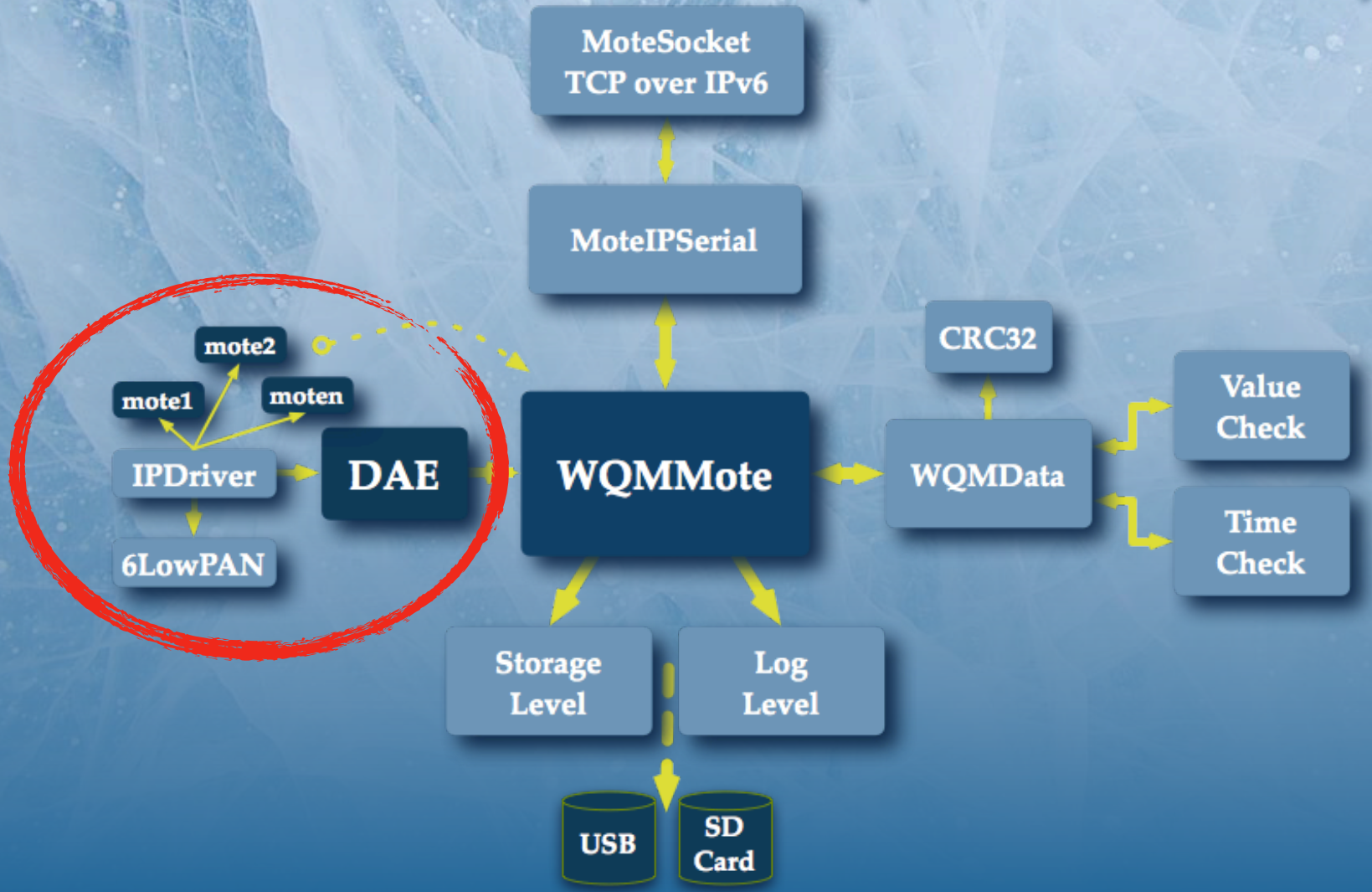
DAE

Mote Network (6LowPAN)



DAE

Mote Network(6LowPAN)



DAE

Contribution

Replica

Serial Communication

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DAE

Contribution

Replica

Serial Communication

Experiments

Wi-Fi

DAE

Serial Communication

Serial Communication

- Blip based TinyOS application - RFSerial
- Send strings of data
- Use of TinyOS' TCP stack - Experimental...
- Connects to IPBaseStation
- Data acquisition - Indispensable!!

Serial Communication

- TinyOS never meant for Real-Time communication
- Data loss...
  - Disable DMA transfer of SPI data - Both FLASH and radio
  - Reduction of atomic statements in TinyOS' branch
- Baud-rate > 19200 bps - IMPROVE!!

Watchdog

Atomic Statements

Bottlenecks

Serial Communication

- TinyOS never meant for Real-Time communication
- Data loss...
  - Disable DMA transfer of SPI data - Both FLASH and radio
  - Reduction of atomic statements in TinyOS' branch
- Baud-rate > 19200 bps - IMPROVE!!

Watchdog

Atomic Statements

Bottlenecks

Serial Communication

Watchdog

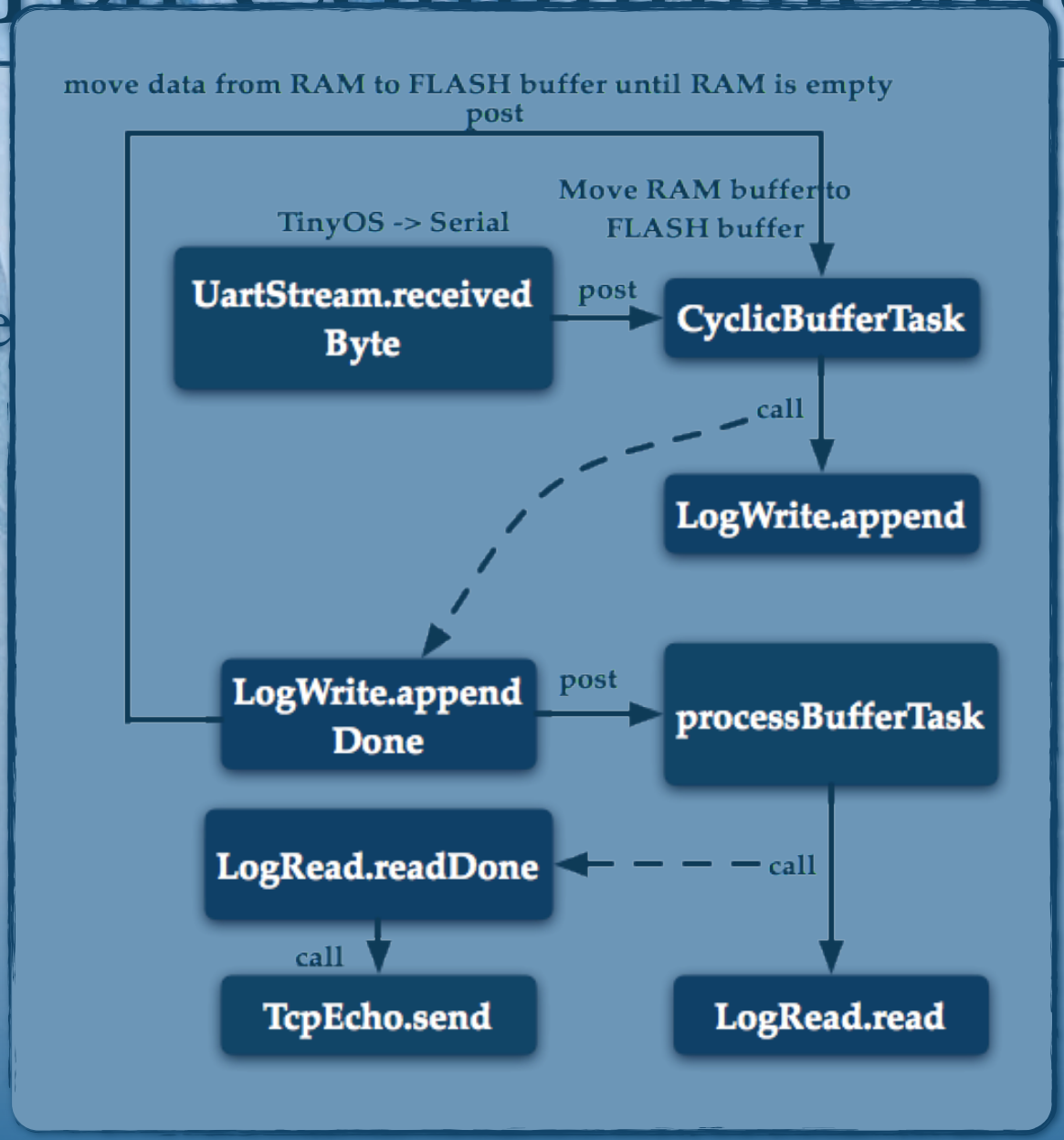
Serial Communication

~~Watchdog~~

- EPFL SensorScope's watchdog to control serial communication
  - Timer based
  - *Touched* when sending a new byte
  - Led to a mote reboot
- Very expensive!
- Client side - Thin client paradigm

Serial Communication

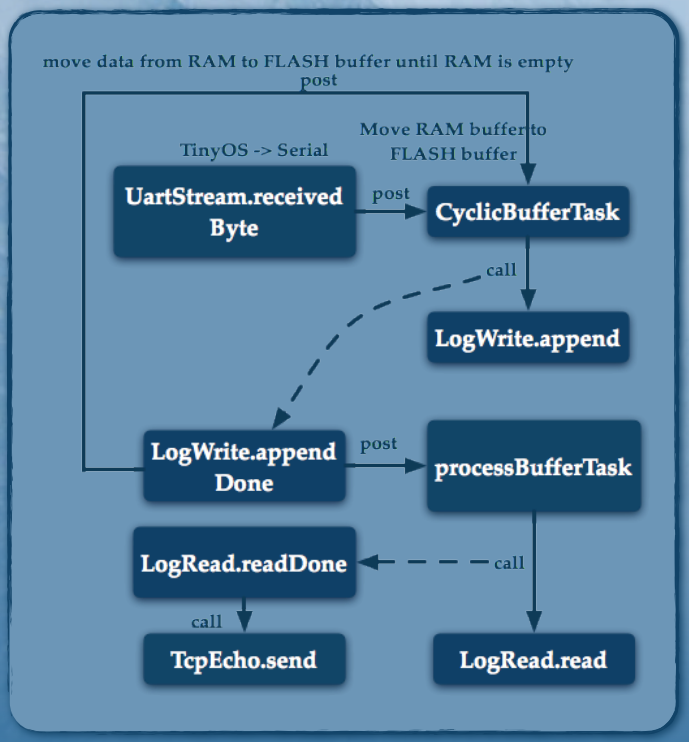
- Code re



Serial Communication

Atomic Statements

- Code reorganization - dependencies

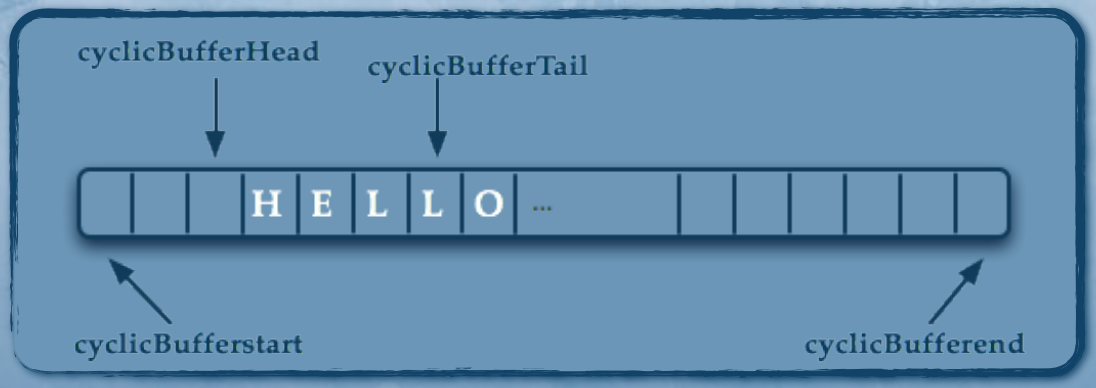


- Improve RAM to FLASH buffer
- Overwritten bytes - data-loss!!
- Beware of Cyclic Buffer
- 38400 bps baud-rate improvement!!!

Serial Communication

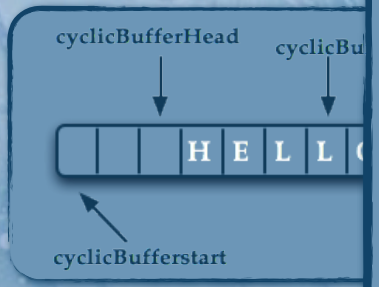
Bottlenecks

- Cyclic Buffer...



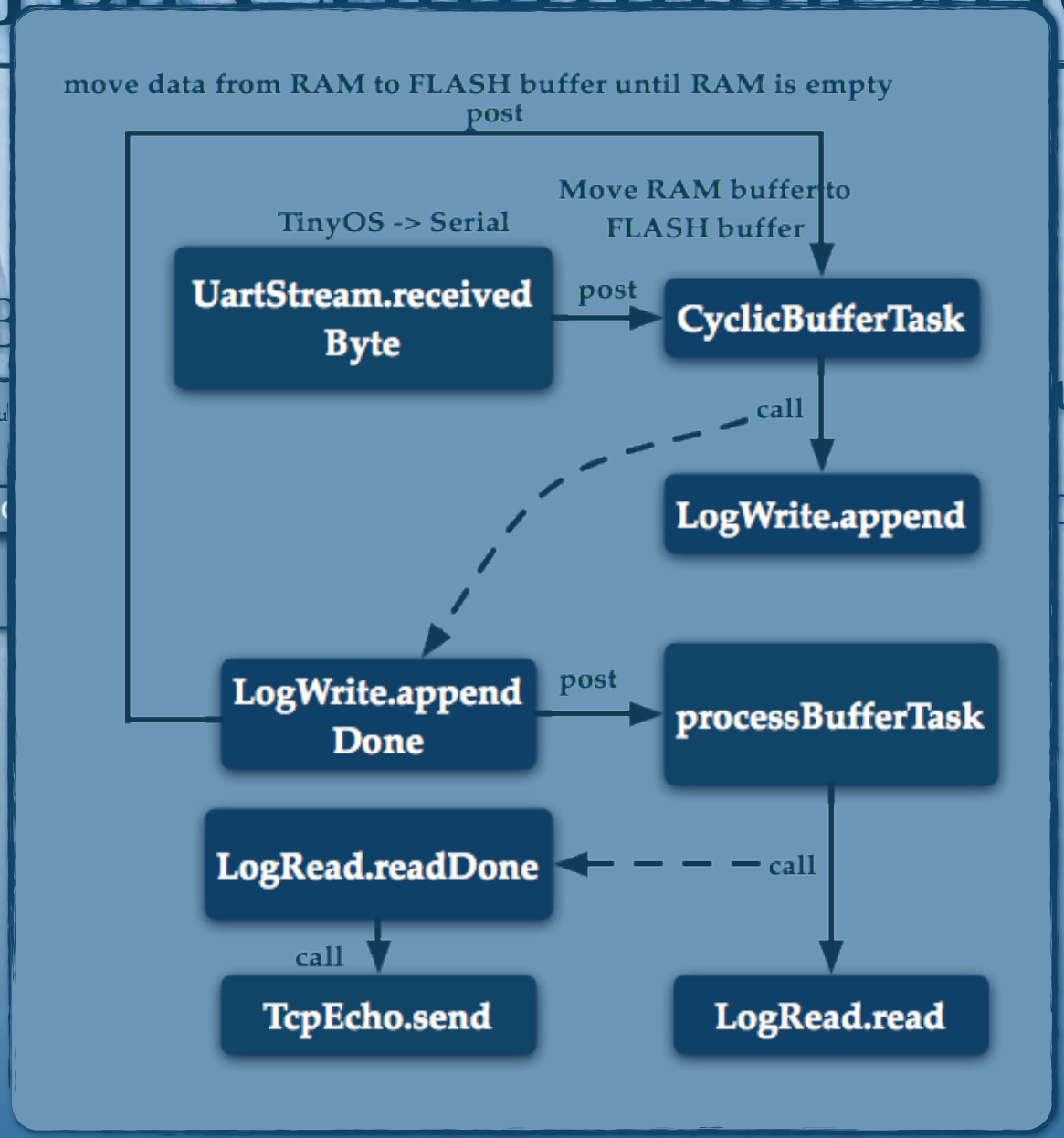
Serial Communication

- Cyclic B



updating

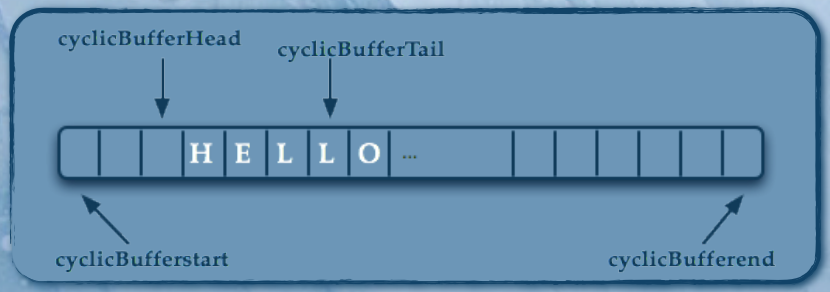
ow



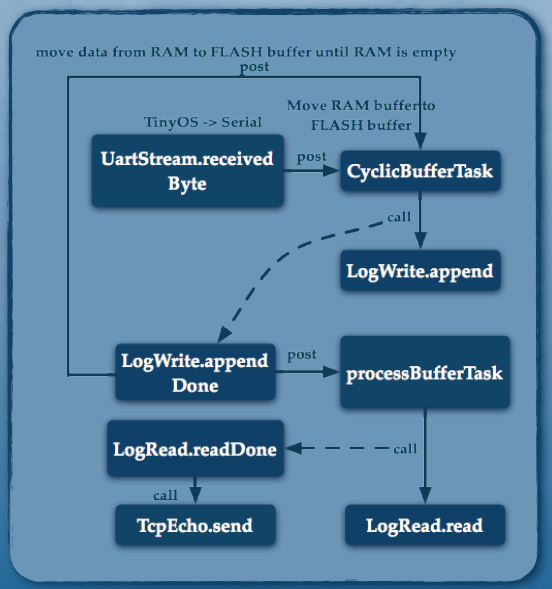
Serial Communication

Bottlenecks

- Cyclic Buffer...



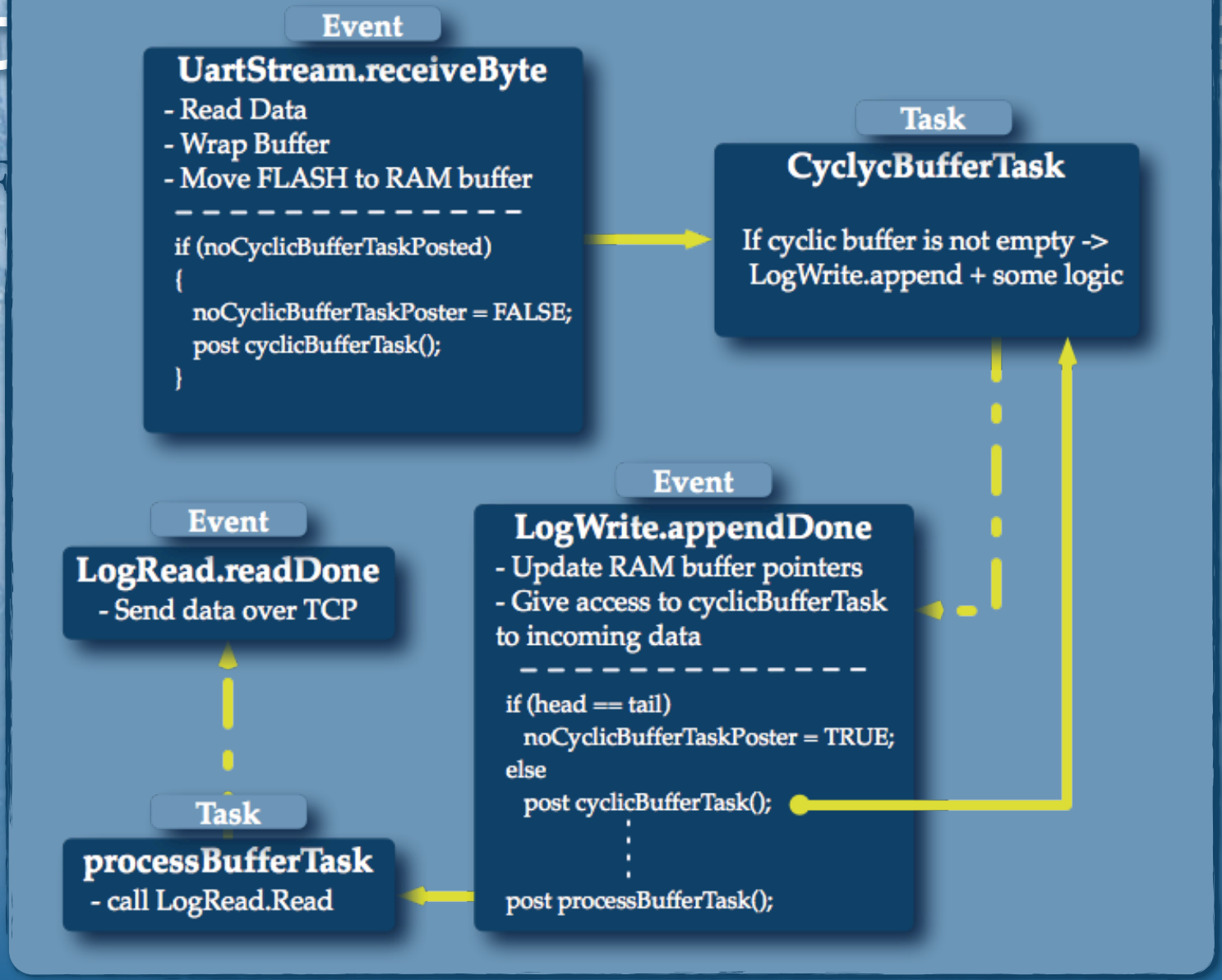
- Speed up pointers' updating
- Avoid buffer overflow
- But deal with it...
  - Trust in data being processed correctly
  - LogWrite.appendDone > cyclicBufferTask
  - Baud-rate... 115200 bps!!!



Serial Communication

Int em

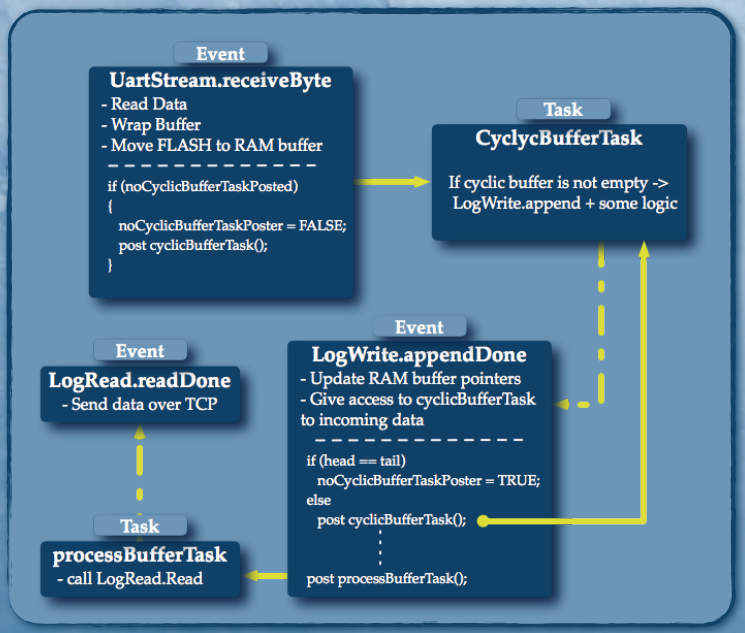
- RF



Serial Communication

Integration with Capoh System

- RFSerial working under DAE - Deadlock!!



- Events and Tasks in TinyOS...
- Interruptions always attended (except for atomic statements)
- Lost events > mote hanging
- TinyOS not meant for Real-Time!
- *noCyclicBufferTaskPosted...*

Serial Communication

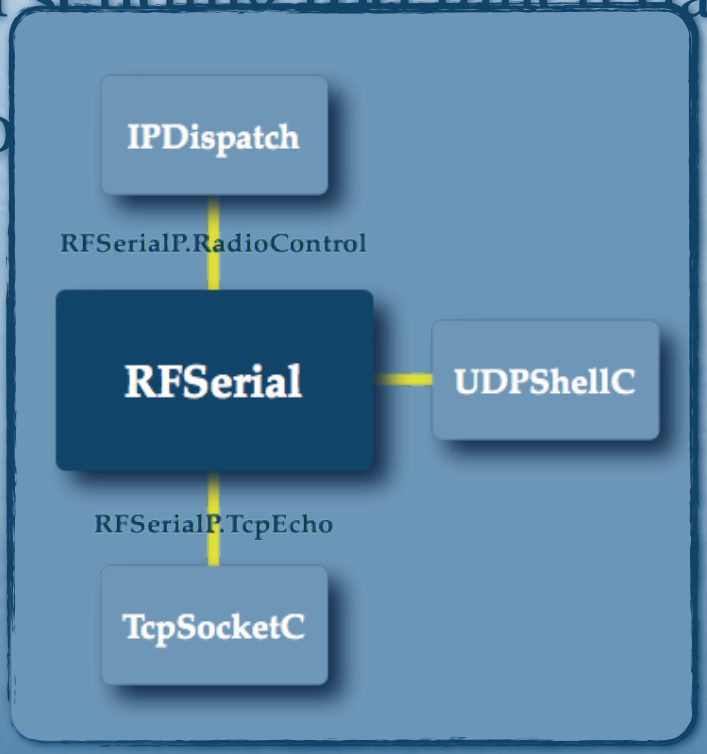
Integration with Capoh System

- Deadlock unavoidable... We deal with it!
- Deadlock-seeking EPFL's Watchdog
  - Checks on *noCyclicBufferTaskPosted*
  - Touch Watchdog when incoming data
  - Releases *noCyclicBufferTaskPosted* when new data received and equals *FALSE*
  - We avoid mote hanging caused by deadlock!

Serial Communication

Integration with Capoh System

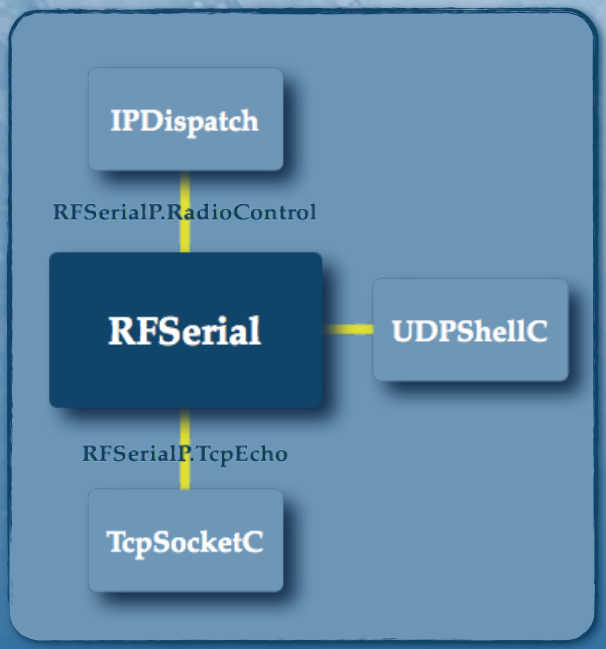
- Problems when sending too much data over TCP...
- Improvement o (in development)



Serial Communication

Integration with Capoh System

- Problems when sending too much data over TCP...
- Improvement of TinyOS' TCP stack (in development)



- *$TOSSDIR/tos/lib/net/blip/TcpP.nc*
- Connection dropped by client after a fixed, random number of bits sent
- Keep connection open until client closes connection or timeout reached

Serial Communication

Serial Communication

Contribution

Replica

Serial Communication

Experiments

Wi-Fi

DAE

Contribution

Replica

Serial Communication

Experiments

Wi-Fi

DAE

Wi-Fi

Wi-Fi

- Very last stage for new generation of data-loggers
- Send data from Base Station to a Server via 802.11
- Data being available in Real Time!! - Analysis, Treatment, Malfunctioning detection, ...
- Qualitative change for unaccessible areas' data collection!!

Wi-Fi

- 4-20 Km from Sommerfuglesø and Langemandsø to nearest Internet access point
- MANA's first version used amplifier and antenna - Very expensive in terms of energy
- Collaboration with Sebastian Büttrich - pIT Lab
  - Power Reduction
  - Antenna Optimization
  - Avoiding the use of an amplifier

Wi-Fi

Contribution

Replica

Serial Communication

Experiments

Wi-Fi

DAE

Contribution

Replica

Serial Communication

Experiments

Wi-Fi

DAE

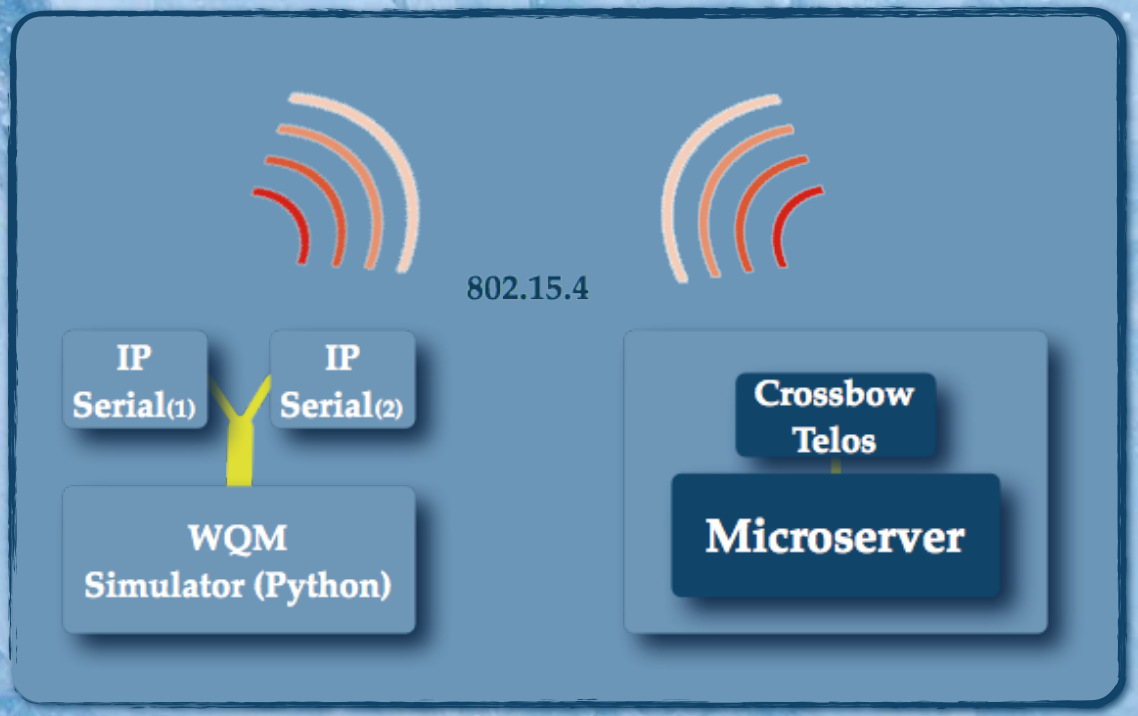
Experiments

Experiments

- So many inconveniences due to weather conditions and expensive hardware
  - Lack of solar panel
  - Lack of PowerStation for 802.11
  - Lack of GPS
  - Use of different Telosb motes
  - Lack of WQM sensors - Indispensable for tests!! (+20000$)

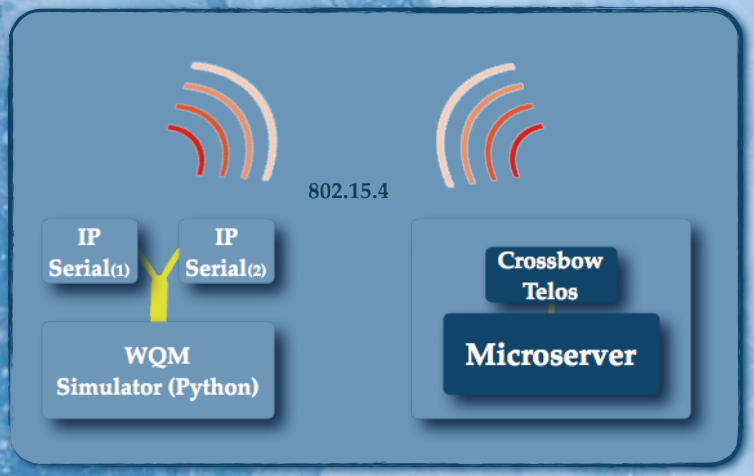
Experiments

- Simulate WQM sensors - Python scripts



Experiments

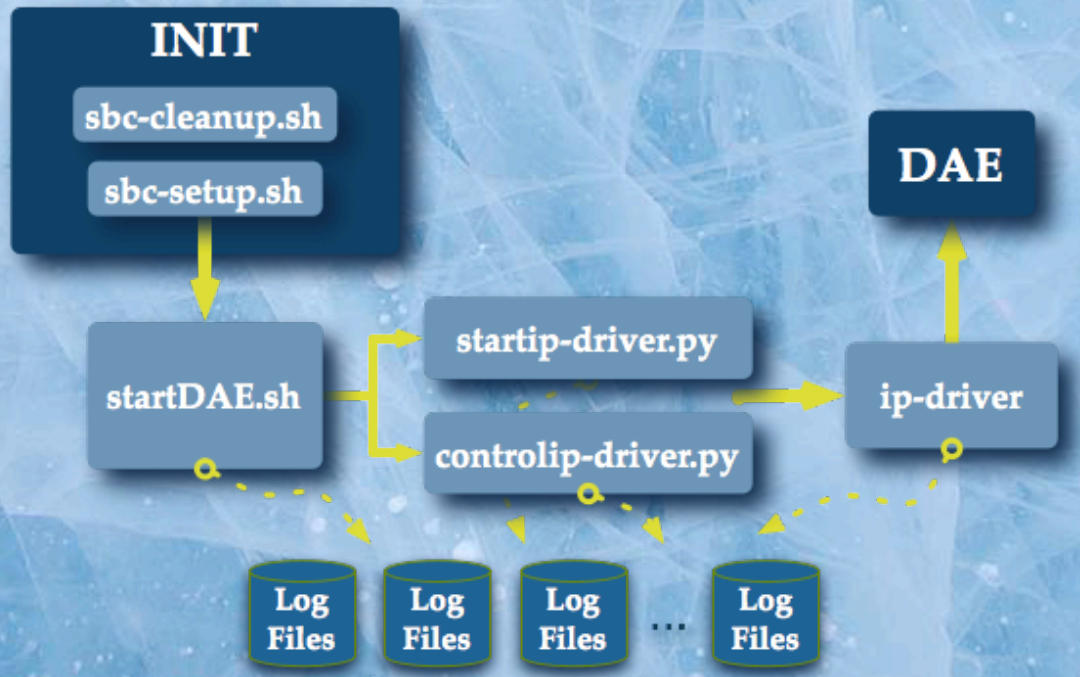
- Simulate WQM sensors - Python scripts
  - Read from serial port - commands sent by the DAE
  - Write in serial port - *fake* data taken from WQM's log files
  - Emulate the complete data acquisition process



- Testbed for MANA's new version!!

Experiments

- Capoh system meant to operate 1 season - 9 months
- Tests can not reproduce weather conditions
- Feedback is always welcome...



Experiments

- System running for 2 weeks - 20min drop-dead & 20min sleep
  - PCS tolerates high-rate operation - reliability
  - DAE is successfully initialized by *scripts* - controlled and uncontrolled inconveniences - recovery
  - DAE handles corrupted data & log it - robustness
  - Log files contain everything - redundancy
  - Contributions have proved to work fine and be integrated - ready for deployment in Greenland

Contribution

Replica

Serial Communication

Experiments

Wi-Fi

DAE

Conclusion

- Objectives:
  - Create a Replica of MANA inside ITU
  - Document previous and new work
  - Provide a Testbed!
  - Integrate our contributions
  - Make some tests and get feedback
  - Obtain a stable system to be deployed in Greenland

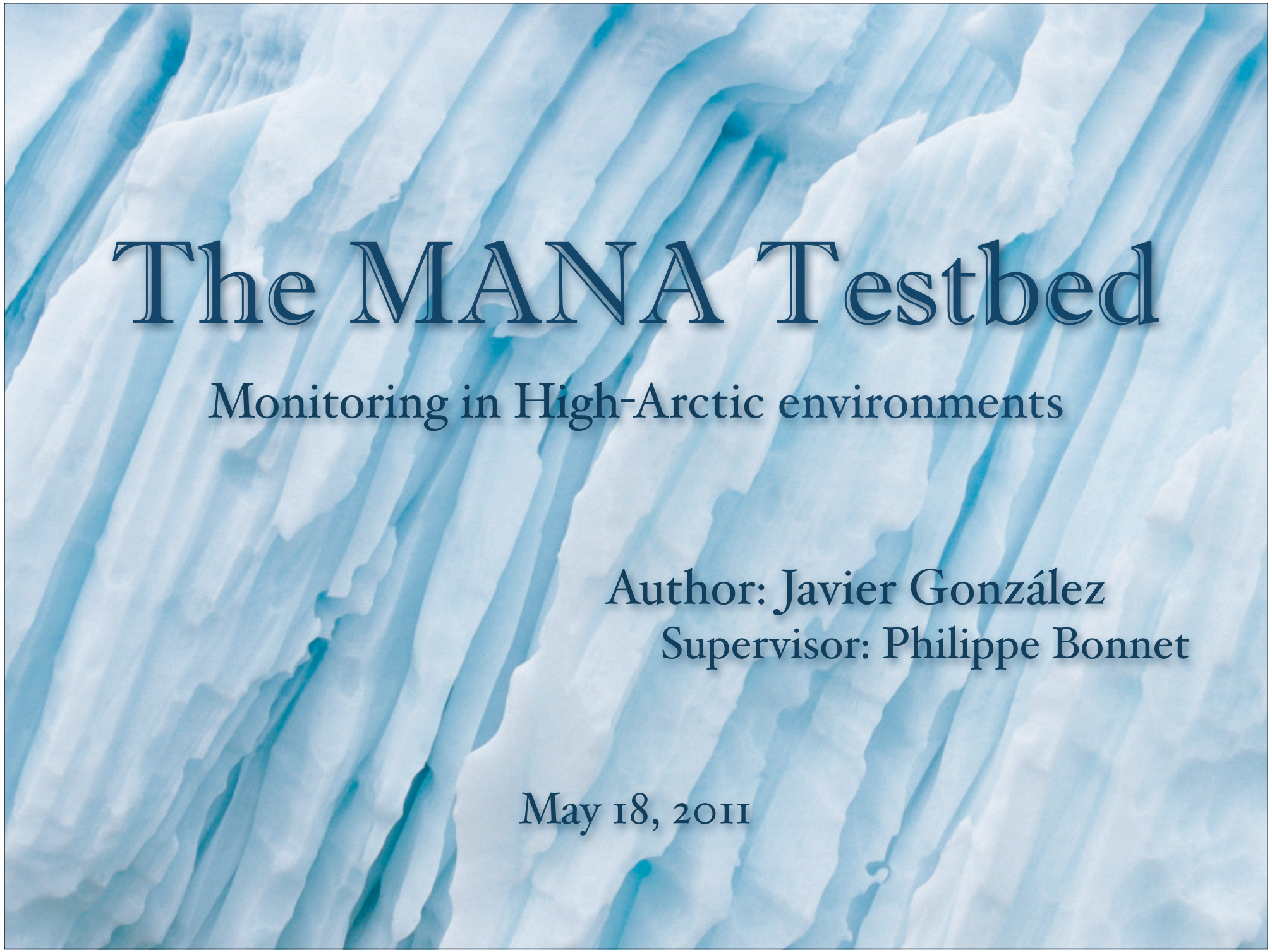
Conclusion

- Approach (Chronologically):
  - Serial communication - TinyOS & RFSerial
  - Build the Replica - Rob Fatland's Vexcel MicroServer
  - Communication between TS-7260(SBC) and PCS
  - Modify INIT sequence in Debian 5 (Lenny) - *Scripts*
  - DAE adaptation to 6LowPAN
  - System Integration - Components altogether!
  - Contribution to TinyOS' TCP stack

Conclusion

- Approach (Chronologically):
  - Serial communication.. Watchdog preventing from mote hanging - Deadlock
  - WQM simulator - Python scripts
  - Test session - Feedback
  - Modifications in INIT *scripts*
  - Renewed version of Capoh Architecture!!!
  - DOCUMENTATION!

Tak for jeres opmærksomhed :)


The MANA Testbed
Monitoring in High-Arctic environments
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Supervisor: Philippe Bonnet
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