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Update to and measurement of the proposed STANAG 5066 extensions to improve ARQ performance

Steve Kille

CEO – Isode Ltd

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Overview

Summary of STANAG 5066 ARQ Problems with WBHF

Specification update based on implementation experience

The Isode implementation

Test Approach

Measurements Made

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STANAG 5066 ARQ Enhancements

- Window exhaustion significantly impacts operation over WBHF
- Two very similar proposals to address this:
  1. Harris: “Recommended STANAG 5066 enhancements for Wideband HF”
     - Presentation at BLOS Comms – Jan 2013
  2. Isode: “Extending STANAG 5066 to improve ARQ Performance over Wideband HF Radio”
     - Whitepaper at www.isode.com/whitepapers/extending-stanag-5066.html
- Isode proposal referred to as “LFSN” (Long Frame Sequence Number)
  - Describes the key change needed to address the window exhuastion issue
  - The change will also be useful for higher speeds of narrow-band HF (so the change is not linked to WBHF although that is the driver)
  - Other changes will be needed for WBHF (at least data rate change)
  - Additional changes to STANAG 5066 desirable

Changes arising from implementation

Added another PDU

- "LFSN-RESET/WIN RESYNC", a variant of "RESET/WIN RESYNC"

Added a new mechanism to negotiate use of LFSN

- Uses a spare bit in the C PDUs used to negotiate Soft Link, requires both ends to actively choose to use LFSN.
- This works in a way that (we anticipate) will transparently not negotiate LFSN for implimentations that do not support it.

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STANAG 5066 SIS gives a natural interface and modem vendors generally supply STANAG 5066.

So why have we chosen to build a STANAG 5066 server?

Why Icon 5066?

- We want WBHF support for our applications now and some vendor implementations are inadequate
- We want Web monitoring and management (many STANAG 5066 servers are PC based)
    - Also need to integrate with application management
- STANAG 5066 Annex L (Ring Token Protocol)
    - Not widely supported or available
    - Essential for multicast and (busy) multi-node deployments
    - Essential for interactive deployments (even two node)
        - Simple soft link will “get stuck”

Icon 5066 is a modem-independent STANAG 5066 Server. Modem drivers are easy to write in Lua (scripting language) by Isode or a partner/customer.

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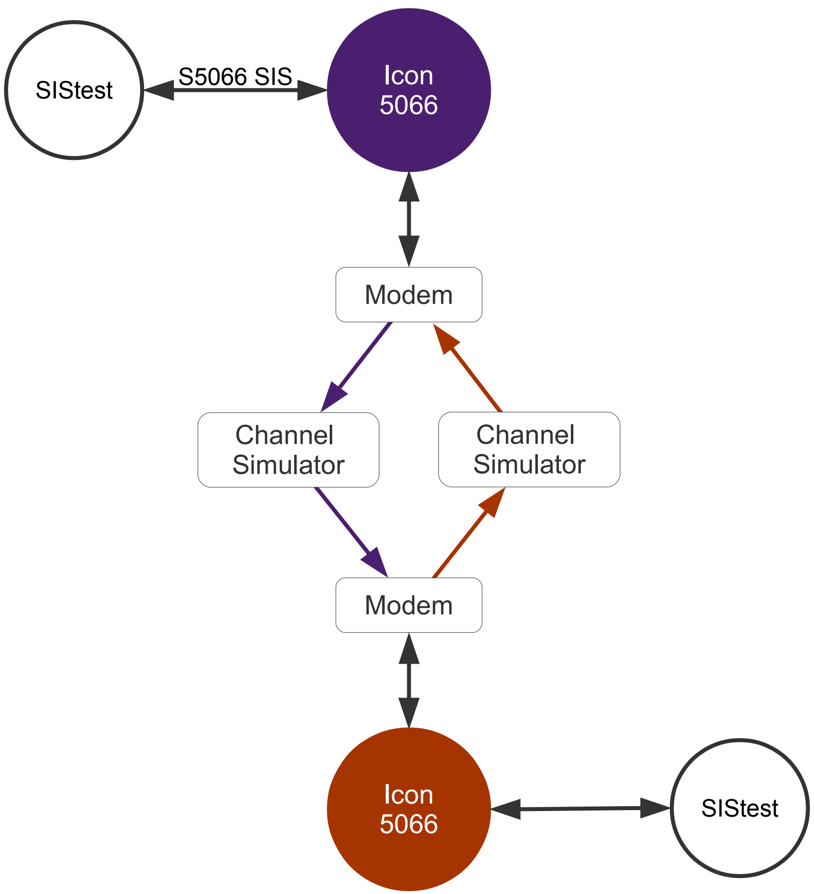
Measuring and Testing

- Need a framework for testing Icon 5066 and for making performance measurements
  - In general and for this talk!
- Front end tool kit to drive tests
  - Written in scripting language (Lua) so that tests are easy to modify and extend
  - SISTest library and tool drives STANAG 5066 SIS protocol
  - Used for measurements in this paper
- OTA testing is wonderful and vital
  - Insufficient access, so most testing needs another approach

Testing with Modems & Channel Simulators

This is a very useful and realistic test approach. Isode has an ever increasing stack of HF Modems (used for the demo after this talk). However, there are limitations:

- Not enough channel simulators (as will be seen in the demo)
- Impractical for testing more than two nodes (even if you have enough hardware)
  - We have multicast applications (ACP 142) and plan STANAG 5066 Annex L
- Awkward for automated (nightly) testing
- Intermediate Term Variation not provided
  - Skywave channels look nothing like a channel simulator for transmissions of more than a few seconds (more details in Jim Peter's talk later)



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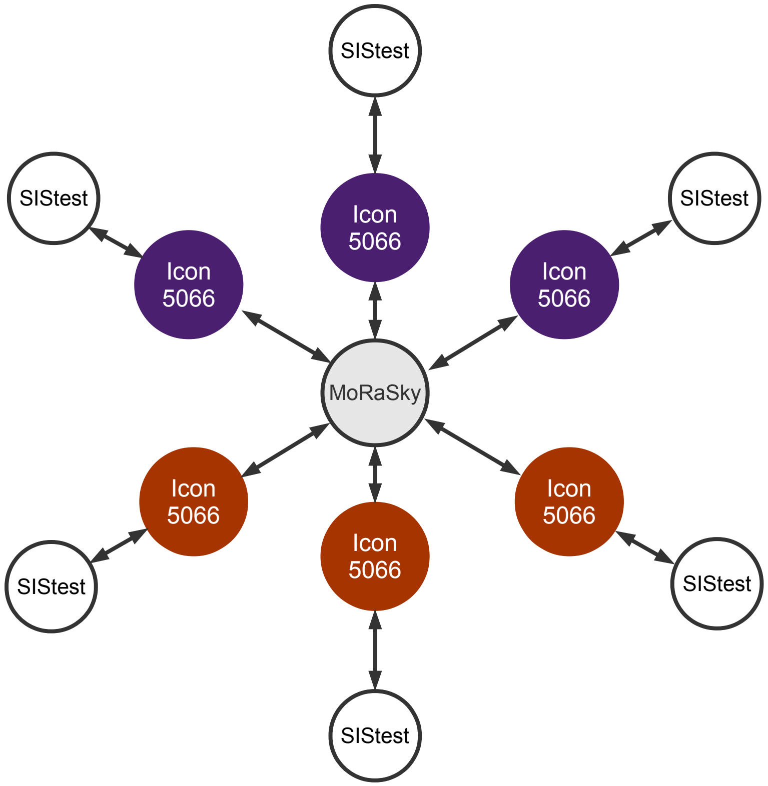
MoRaSky (Modem, Radio, Sky)



MoRaSky simulates HF Modems, Radios and the Ionosphere.

- Java programs for use by Isode and Isode partners for testing and measurements
- Used for some of the measurements here
- Waveforms emulated: STANAG 4539; STANAG 4285; STANAG 4415; MIL-STD-188-110C Appendix D (WBHF)
  - Timings and data deal with block sizes/interleavers
  - Channel conditions; CCIR values; AWGN
  - Modem timings and propagation delays
  - Characteristics derived from measurements with real modems over channel simulators

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MoRaSky

- Underlying Ionosphere model allows emulation of long term trends based on SNR
- Can also configure error rate and error clustering
- Intermediate Term Variation
  - Based on Walnut Tree Model applied to modem data
  - Will add improved emulation based on recent OTA Skywave Measurements
    - More details in the talk by Jim Peters
  - Would be good to have groundwave OTA measurements (ideally over water) to supplement this

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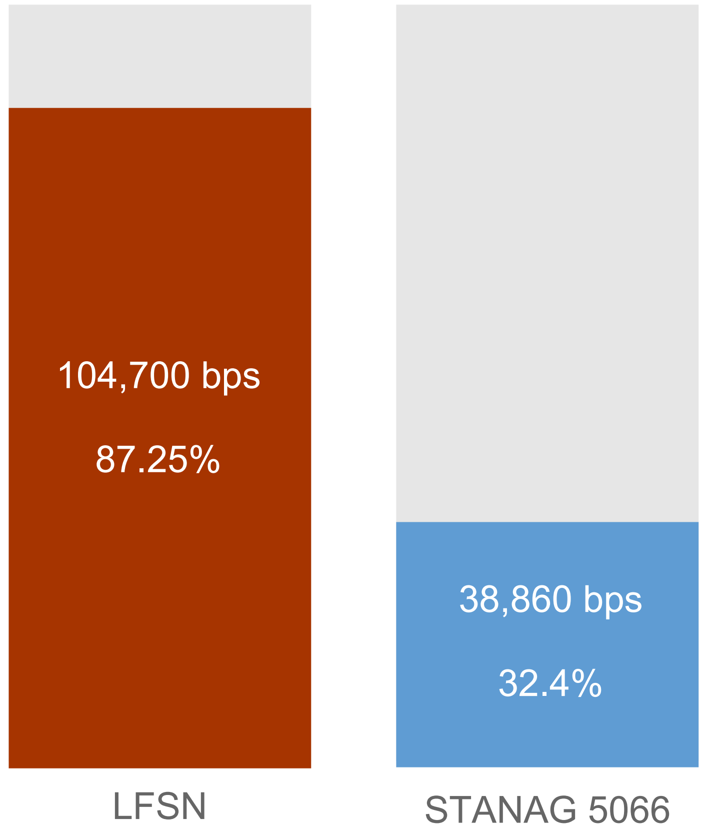
STANAG 5066 LFSN Test over "perfect link"

- Tests over 120,000 bps WBHF link
- Based on repeated runs of approximately 5 minutes
- Identical number for
  - MoRaSky
  - Rockwell Collins VHSM 2050 WBHF modems with audio back to back links
- LFSN eliminates a lot of hand-shaking to achieve significant performance gain



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Why LFSN helps so much

- STANAG 5066 protocol overheads are very low (approx 2-3% for 1024 byte DPDUs)
- Turnarounds are the major overhead in these scenarios (approx 6 seconds/turn-around, reducing throughput by approx 6%)
- With LFSN you get one turnaround approximately every 127.5 seconds
  - At 120 kbps, you get around 10 “extra” turnarounds in this time due to window exhaustion
- Reducing turnaround time is hard
  - Reasons examined in next slide
  - In real deployments turnaround times may be even longer
- To get good throughput over HF, including WBHF, you need to minimize turnarounds
  - This means long transmissions
  - Implications all the way to the application level

Why Turn-around time is hard to reduce

The key elements of turn-around time for one-way data flow are shown below. We should strive to reduce these times. However reducing to a level where turn-around time is “negligible” seems impractical.

Skywave Time (*2)

0.5 seconds

Radio Switching Time (*2)

Crypto Initialization Delay (*2)

Waveform Sync Time (*2)

STANAG 4539 Slow: 0.4 or 4.8 seconds

STANAG 4539 Fast: 90 mS (plus up to 539 mS TLC)

WBHF: 133ms (plus up to 11.3 seconds TLC)

Transmission Level Control (TLC) set to suit radio and operating conditions

Reverse Transmission Time

If data isn't flowing the other way no need to count this (and consider others as *1)

Block size: 0.1 - 10.24 seconds

Clear case for asymmetrical parameters with slower speed on acks (they are important) and smaller block size

DSP Time (*2)

Time to process final block (more work for long block and high speeds)

2 seconds measured for 120 kbps and Long interleaver

Clear case for using slower speeds and shorter interleaver for acks

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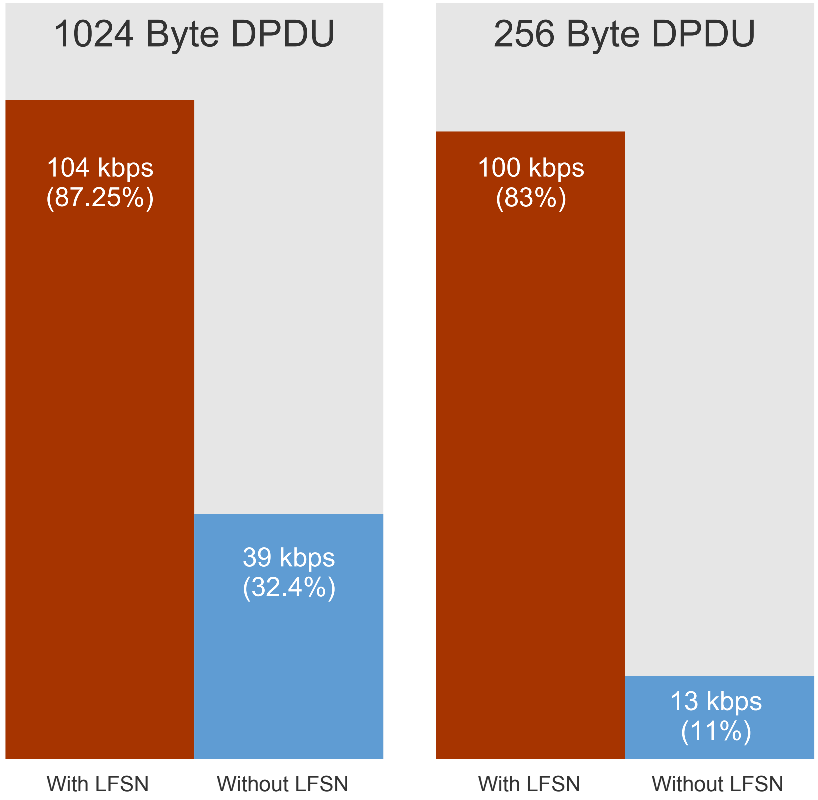
Smaller DPDU Size

- Reducing DPDU size to 256 has small effect with LFSN
  - Simply reflecting higher overhead of smaller DPDU
- Massive effect if LFSN is not used, due to additional turnarounds
- Shorter DPDU probably not sensible for Skywave
  - Jim Peters will discuss this afternoon
- May well give performance gains for Groundwave
  - See AWGN analysis in my HFIA talk for February 2014



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Results with Link Errors

BER	FER (1024 bytes)	With LFSN	Without LFSN
Perfect Link	0%	104 kbps (87.25%)	39 kbps (32.4%)
10^{-6}	0.8%	104 kbps (87.25%)	19 kbps (15.5%)
10^{-5}	8%	73 kbps (61%)	4 kbps (3%)
10^{-4}	80%	17 kbps (14.5%)	0.4 kbps (0.3%)

- x% FER will lead to approximate throughput degradation of order x% when LFSN is used
  - For APDUs affected by errors, latency will increase dramatically
- If LFSN is not used, errors will cause window to close up
  - This increases number of turnarounds and throughput degradation is very significant

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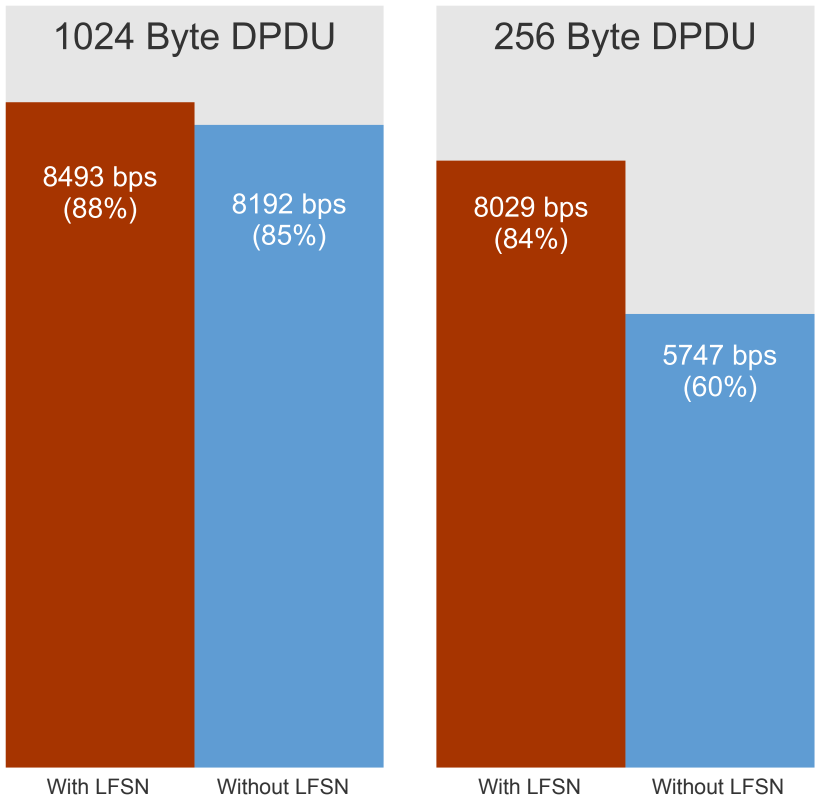
Results at Narrowband speeds

- At 9600 bps, LFSN gives marginal improvement for 1024 byte DPDU
  - Transmit length reduced slightly without LFSN
- For 256 byte DPDU, LFSN performance benefits are clear
- Shorter DPDU sizes can be beneficial for performance at 9600
  - Jim Peters talk will look at this
- At 9600, performance without LFSN will be significantly impacted by even small error



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Conclusions

- The LFSN (Long Frame Sequence Number) extensions to STANAG 5066 deliver significant ARQ improvements for WBHF
- It also gives useful performance improvements for the faster narrowband HF speeds

Demonstration in the next session

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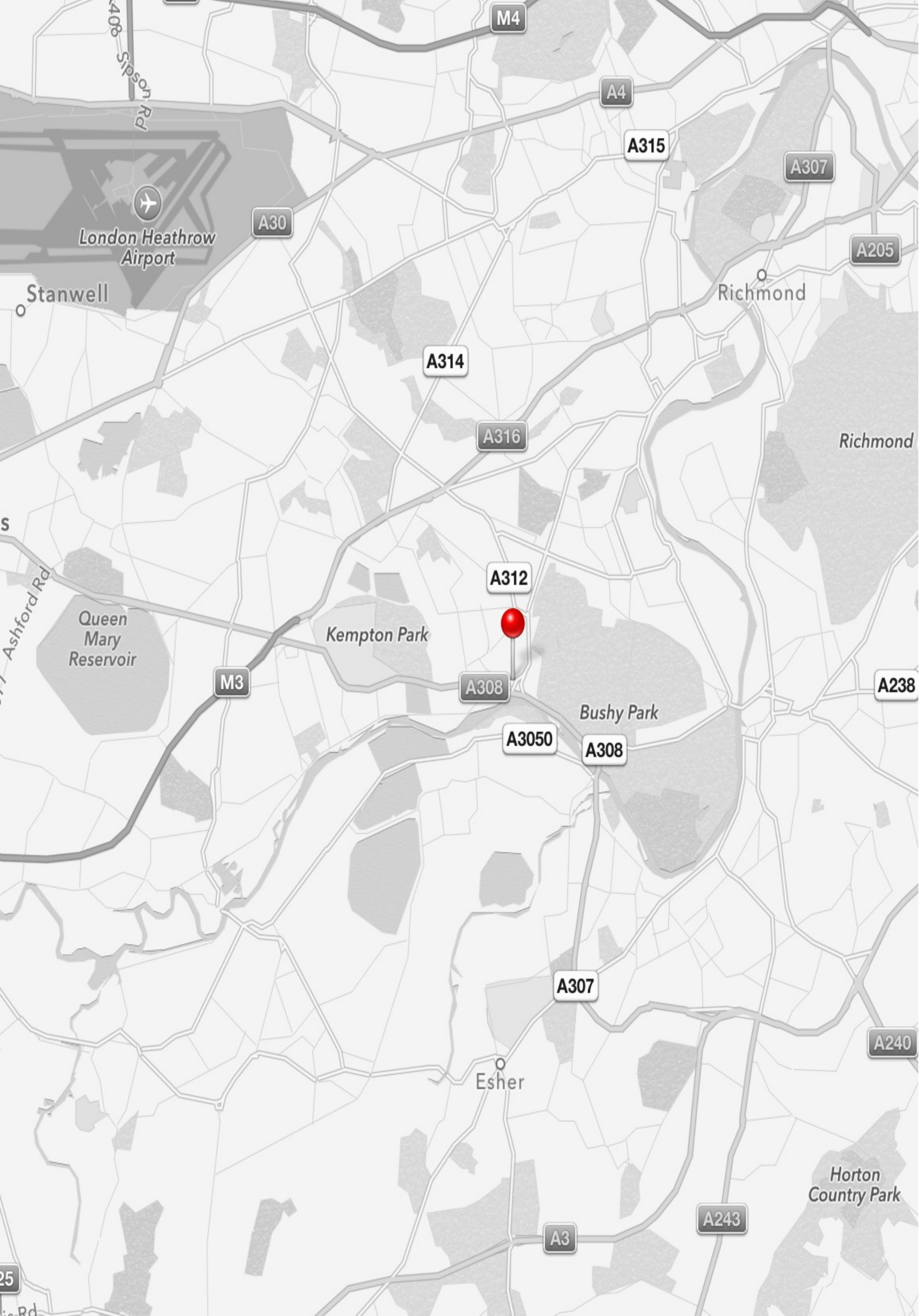

Contact Information

Steve Kille

steve.kille@isode.com

Isode Ltd
14 Castle Mews
Hampton
TW12 2NR

www.isode.com

twitter.com/Isode_Ltd
linkedin.com/company/isode-ltd

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