OBSERVATIONS AND COMMENTS CONCERNING PRACTICAL UNDERWATER ACOUSTIC COMMUNICATIONS

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QUESTION: What is missing in practical acomms systems?

There can be significantly different drivers for commercial, academic, and military users. There are also common drivers that need to be addressed.

This brief talk presents some of my observations based on many years of involvement in all aspects of acomms:

- Academic Studies and Commercial Modems
- Modem placement
- Networking
- Standards
- Benchmark testing/demonstration
- Regulatory Issues

Personal Background

- Sonar and acomms R&D – too many years to remember them all
- BA in Math and 3 Masters Degrees in Engineering and Physics
- Provided initial definitions for the NATO standard relating to digital acomms – JANUS
- Served as Vice Chair for NATO Industrial Advisory Committee for JANUS
- Chief Scientist for Teledyne Benthos

- Now happily retired and providing occasional consulting services

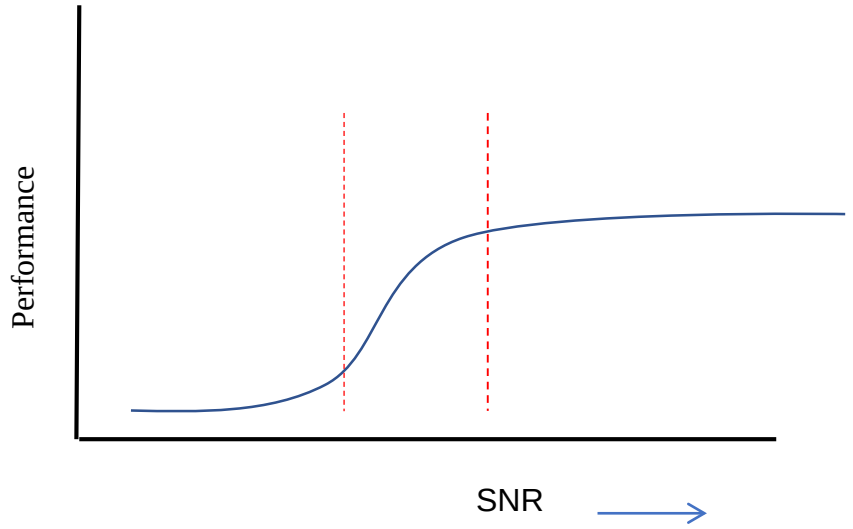
Academic Studies and Commercial Modems

- Most commercial modems use a single transducer – an array adds significant complications
  Studies/experiments involving arrays, especially long VLAs, are (perhaps) of limited practical value

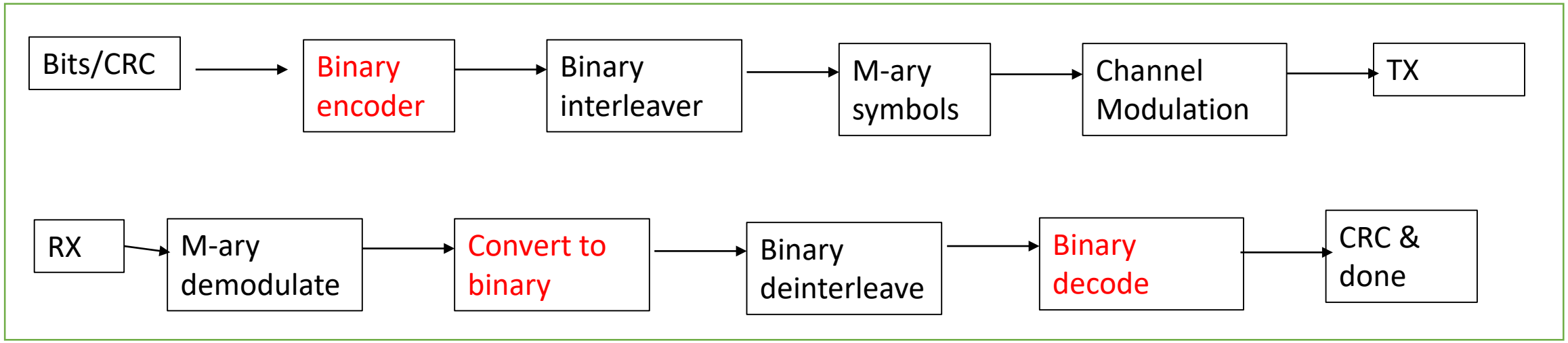
- A potential opportunity for modem applications is within the offshore oil and gas industry.
  What is the noise/interference environment near infrastructure?
  What are the multipath characteristics near the infrastructure?

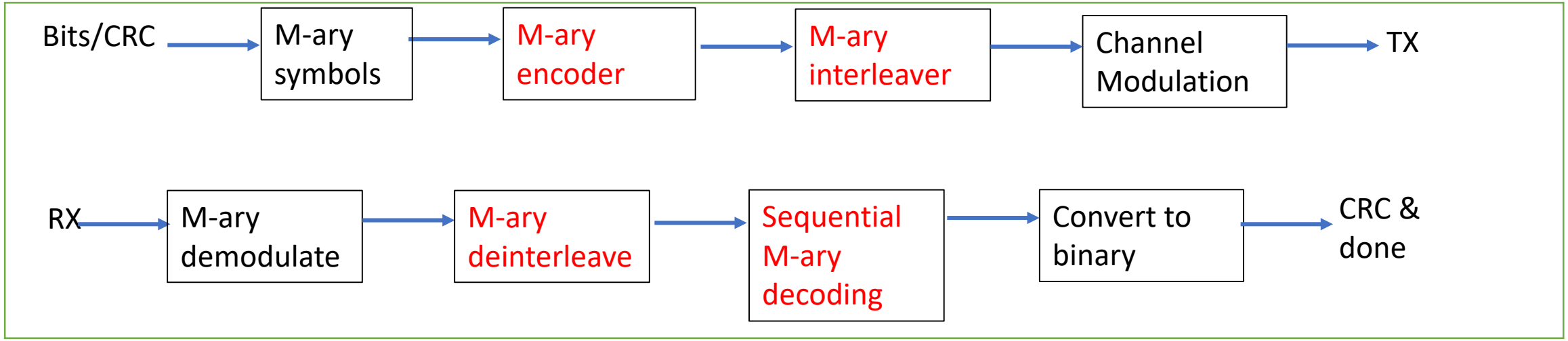
- Modems placed close to infrastructure experience strong reflections. Presently lead-based SADM is fairly effective in absorbing acoustic energy. It is toxic and VERY heavy. We need alternatives

- Extend the Transition Region



Physical Layer Suggestion For Extending the Transition Region





- Use very long constraint, M-ary encoding – expect some gain in performance
- Avoid inefficiencies in converting demodulated M-ary symbols to assumed binary equivalents – expect some gain in performance

Modem Placement

You have two modems to be deployed in intermediate depth water. You place one near the sea floor. At a range of XX km, at what depth should you place the second for “best” performance?

A real world anecdote from a fresh water lake…

Not everyone can call Mike Porter at HLS for a quick analysis of local propagation conditions. Not everyone has access to “easily” understood channel models – indeed, not everyone can understand a ray trace graphic.

The community needs a simple model available on a micro-computer that will predict the relative received levels given deployment depths for two modems.

Equalizer tap allocation

Consider a coherent acomms scheme which relies on an adaptive equalizer for demodulation.

How do you measure the channel impulse response to answer the following:

1. How many taps do I need?
2. If the channel is sparse, how do I effectively allocate my taps?

This may be too mundane for academic research, but it constitutes an important technology gap for commercial modem vendors.

Network (and higher layer) design

Network designs, as presented at academic conferences, are frequently discussed as solutions without application. No one tells me why I should care about the design.

Designs are (almost) never presented with reference to experiments and/or realistic simulations using realistic channel models.

I suggest that a sponsor (NSF ?) establish several practical applications for acomms requiring a network solution. This requires a commonly accepted, high fidelity, time-domain simulation incorporating time-varying CIR, interference, and relative motion.

Network design is very important, and the need for this is going to increase, but the community first needs STANDARDS

Performance Measurements

For much of the past 15-20 years, ONR funded the development of modems, primarily the WHOI Micromodem, with some funding for specialized purposed to other developers. Other US government agencies funded the development of alternative, perhaps special purpose modems, while NATO and the EU provided development funds for European technology.

To this date no one really knows the relative capabilities of the various vendor offerings. Within the US, there has not been a single opportunity for a formal evaluation of relative performance among modems. Indeed, within ONR this historically was a topic that simply could not be discussed.

Is this an issue that the academic community (NSF?) needs to consider? Should NSF establish performance metrics as a means of evaluating the value of funded research?

STANDARDS

We will have a presentation later in this workshop from NATO CMRE concerning the processes developed and followed in establishing the JANUS modem as the first NATO digital acomms standard.

The JANUS standard (a NATO STANAG) defines what a modem should do. It clearly formulates a complete transmitter. It provides guidance on what a receiver should accomplish, accompanied by a Matlab implementation of a basic, but effective receiver. It established metrics for graded performance under a variety of scenarios and applications. It involved participants in virtually all areas of R&D, commerce, and military to make it as generally useful as possible.

The community really needs more such standards for other modulation schemes, for networks, for transducer design, etc., etc.

Regulatory Issues

May I suggest you consider the following statement?

"Any type of telecommunications equipment having any of the following characteristics, functions, or features:

……..

(b.1.a) An acoustic carrier frequency outside the range from 20 kHz to 60 kHz"

- If you are thinking of spinning off your own company, you must be aware of this, and other, export regulations. Offline discussion??

SUMMARY

This is a compilation of personal thoughts and observations from someone who has been in this business for quite some time

In the commercial world we need the following:

Move the transition curve – Maybe incremental improvements are “enough”

Standards and agreed processes – look to JANUS and CMRE as models

Practical network design – start with the CONOPS

Opportunities for performance benchmarks – comparative testing for government evaluation

Much simpler propagation modeling – just tell me how deep to place my modem

Regulatory transparency – why does DoD say “no”?