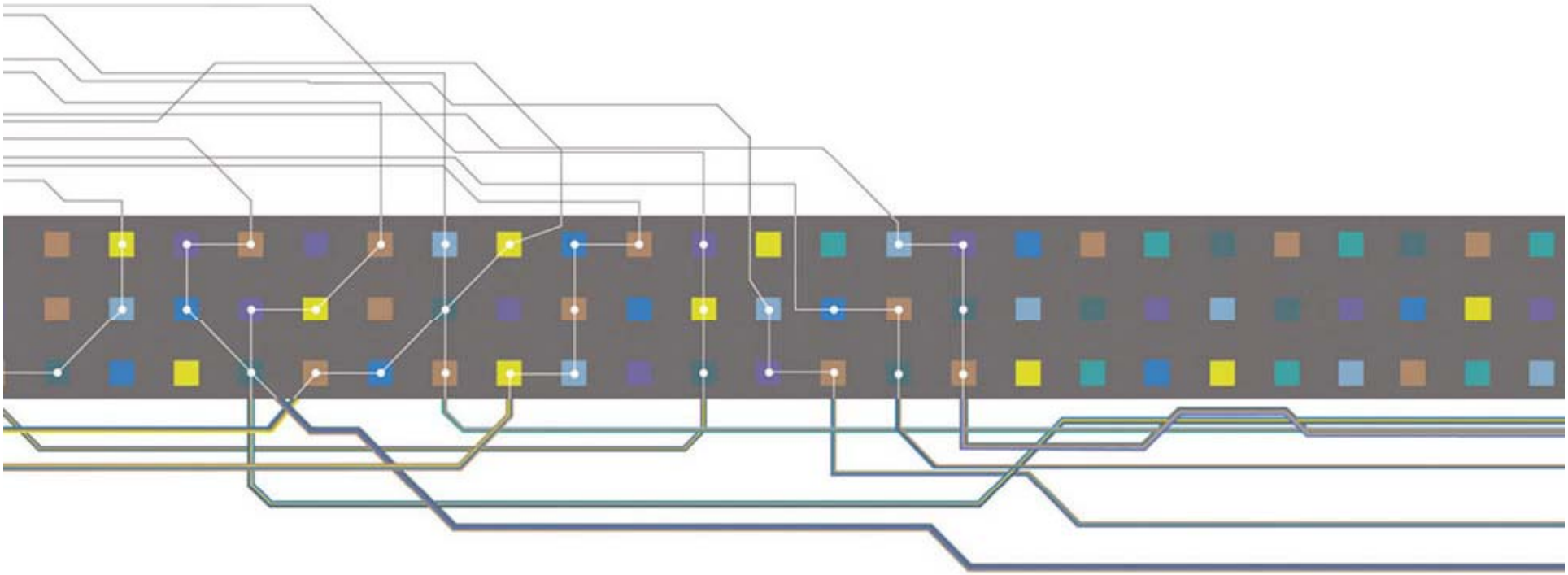
THALES



Further Analysis of Single Frequency vs. ALE Supported Nets for Maritime TacWAN Applications

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Standards - a personal perspective

- Successful HF STANAGs / standards appear to be related to the following factors
  - Truly open and freely available to industry
    - Have clear multi-vendor industrial support
  - Developed to meet a defined requirement /user need
  - Provide good performance under a range of conditions for more than one user community
  - Cost effective to implement
    - Size of potential market /UPC /NRE
- Examples (at the current time)
  - MIL STD 188 141A – 2nd gen ALE
  - STANAG 4285 / MIL STD 188 110A
  - STANAG 5066 v1.2 + CFTP (BFEM)
  - STANAG 4539 / MIL STD 188 110 B

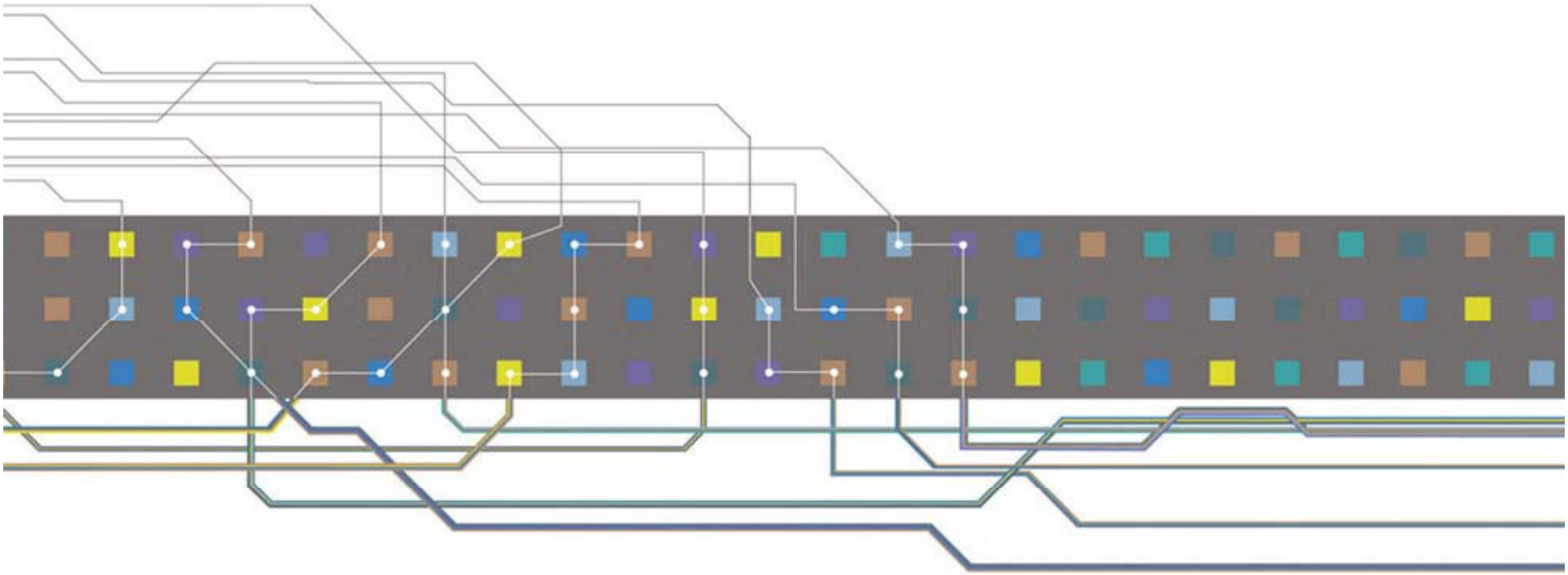
Standards - a personal perspective (2)

- Less successful standards : ***not necessarily related to less successful products***
  - *My Defn : A standard that has only been adopted by one user community and/or is not widely used*
    - Driven by one user community / application -
    - Expensive to implement (Usually has more hardware linkages/ implications)
    - Limited range of applications that provide good performance
- Examples (at the current time)
  - STANAG 4444
    - development started early 1990s
  - STANAG 4538 / MIL STD 188 141B - 3rd Generation
    - Outside Army Tactical radio applications
- ***STANAG 5066 v2.0 ??***

TACWAN - Single Frequency Channel Access

- What is the perceived HF Channel access problem
  - Multiple users accessing a single HF common frequency
- Where did the requirement arise ?
  - Limitations of BFEM – 66 (possibly)
  - Perceived lack of IP support over HF (possibly)
  - Need for relay (but channel access does not solve this problem)
    - ALE provide BLOS links directly
- Why a single frequency given that
  - Severe performance limitations
  - Difficulty in configuring system to work reliably with ARQ
  - Difficulty in choosing a suitable common frequency : co-locational issues
- Lack of ALE ?
  - Most modern HF radios support ALE – JTRS will provide ALE
- Required for simultaneous multi-cast
  - What application necessitates this – CHAT ?

THALES



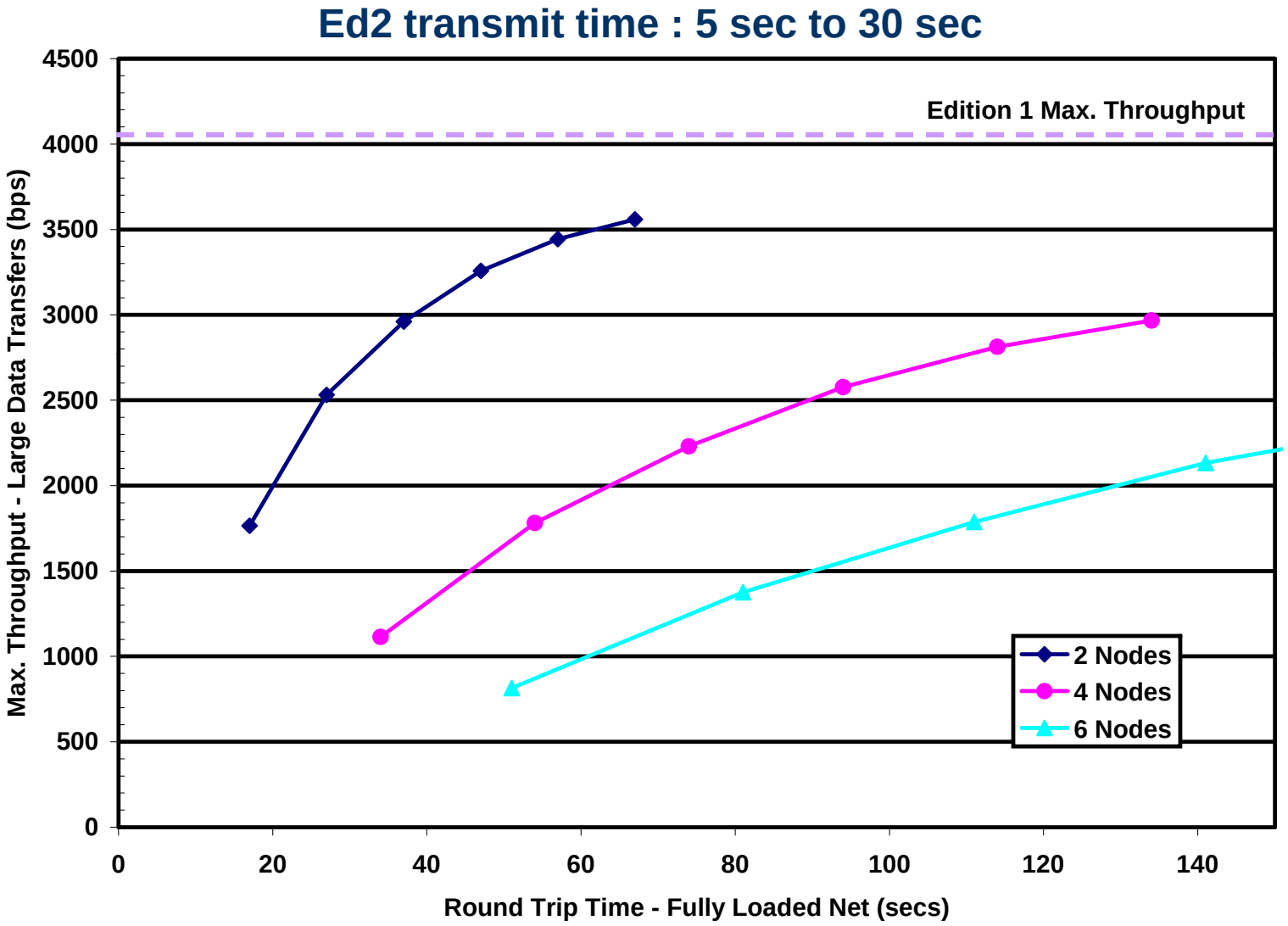
Single Frequency Performance Analysis inc. Some 5066 Aspects

Land & Joint Systems

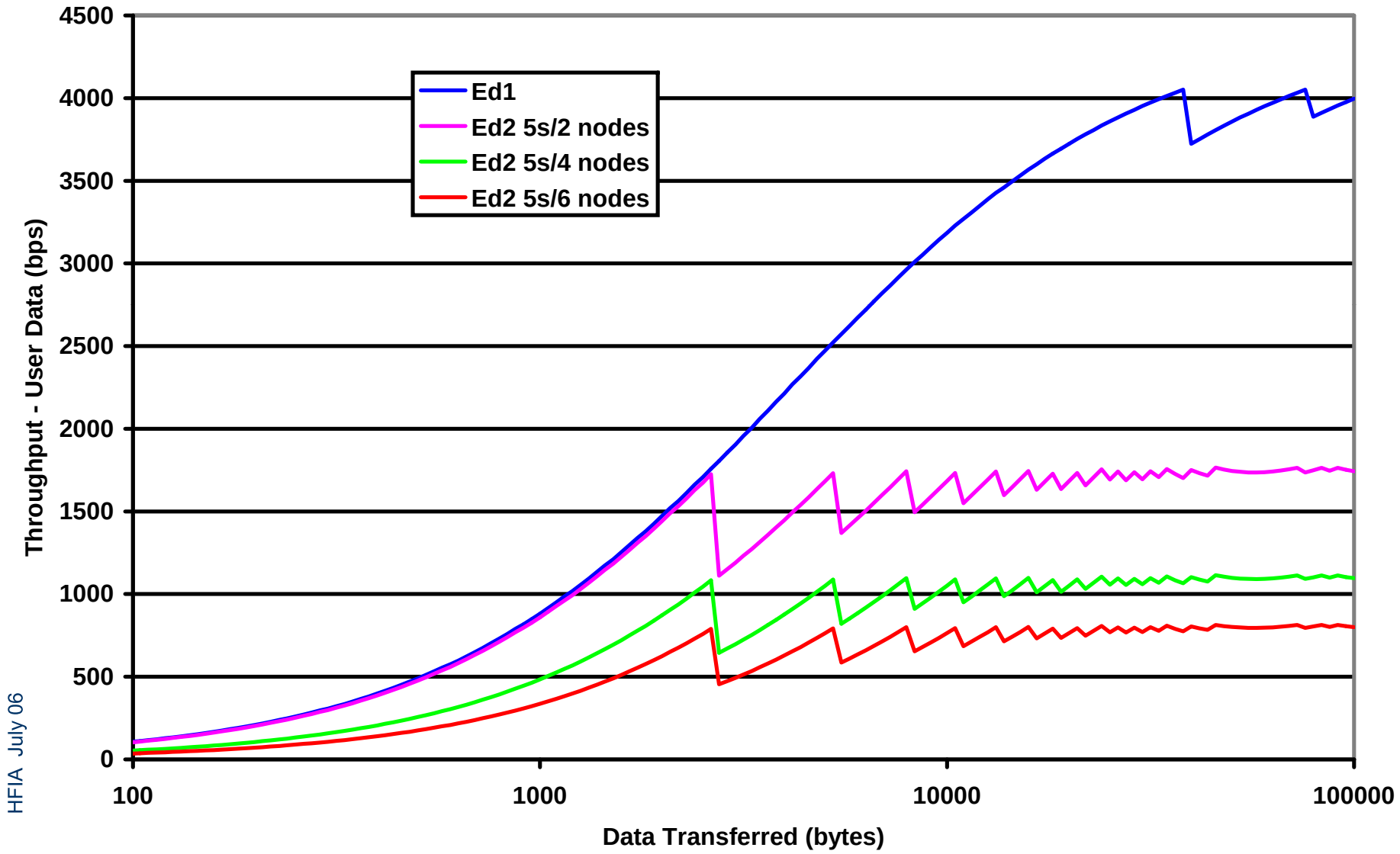
Single Frequency Network Operation (1)

- Fundamental limitation is that bandwidth available to an individual user is reduced in proportion to number of users sharing the frequency
  - (and heavily influenced by link turn-around time)
- HF radio example (from ref 1)
  - 5 NODE network
  - Link turn around time of about 1 sec approx. the minimum achievable with COTS PC and HF Modem and VS interleaver
  - On air rate of 6400 bps (error free)
- Total network throughput ~ 5000bps (Token/TDMA) or 2500 bps (DCF/DCHF)
- On average each user will get between ~1000 bps (token/TDMA) and ~500 bps (DCF/DCHF) on-air (NOT end to end) data rate
- These figures do not include ARQ overhead or make allowance for application + protocol overheads, TCP/IP initialisation etc
  - ref 1 : “Impact Of Turnaround Time on Wireless MAC protocols” - Prof E Johnson

Throughput vs. RTT : Varying Transmit Time



Throughputs: 4800 bps, S Interleaver



HF Token Ring - Single Data Rate Issues

- A common data rate is typically used for all users in the network
- Chosen rate must work reliably over the maximum range between any two users in the network
  - Doesn't allow for local RX conditions on platforms
  - Doesn't allow for variations in installed antenna radiation patterns i.e lack of ideal omni-characteristics /frequency dependency
  - For a user at the “edge” of a HF network communications may be 1200 bps, or less, while 9600 bps could easily be achievable at between other users only separated by 25 miles range
- To be reliable a single data rate system must use the “lowest common denominator” data rate : which may be significantly i.e ~100 ..800% lower that achievable over the shorter ranges
- How to choose a suitable common data rate ?
  - Requires prior knowledge of likely operating conditions

Some Submarine-Related Issues

- Network joining
  - Network “solicits” for nodes to join (one “solicitation” per net cycle time)
  - Access time increases with: number of nodes in net, configured “Right to Transmit” time
  - Not good for platforms requiring timely, ad-hoc network access (e.g. submarines)
- Other problems for submarines:
  - Platforms must transmit the token even when no data to send (no “EMCON” operation)
  - No provision for asymmetric comms links
  - No possibility of automated/adaptive power control – transmissions must be capable of reaching several nodes

More Token Ring Issues

- Choice of Right to Transmit Time (RTT)
  - Too short : throughput at the HF link layer (ARQ) decreased particularly for data intensive applications
  - Too long : user latency increased
    - reliable configuration of ARQ protocols either HF 5066 or IP – TCP problematic
    - response time for interactive applications e.g. HF CHAT may be too slow
- Choice of time-outs for reliable token loss identification difficult
- Reliable token transfer
  - Long interleaver more robust but decreases overall network throughput : possibly use short interleaver with multiple repetitions of token
  - Many COTS HF modems cannot switch interleaver settings without significant delays
- Token recovery
  - A long RTT improves pt-pt throughput but token loss will not be identified for some time
- Choice of a single common frequency
  - Doesn't allow for local platform issues e.g problem due to local inter-modulation : cross channel coupling

ALE – Benefits

- Increased Bandwidth
  - For multi-user scenario users can share a common ALE scan-set and work on multiple frequencies simultaneously
    - 8 users could be using 4 separate frequencies for pt-pt links
- Individual Link Optimisation (increased throughput)
  - for **each** pt-point link ALE can choose the frequency with the highest Link Quality Analysis (LQA)/SINAD value
  - LQA can be used to initialise the traffic data rate used on the link to the highest rate compatible with the channel conditions
    - Maximises throughput when STANAG 5066 ARQ used with an autobaud waveform such as STANAG 4539
- Automatic BLOS /LOS /Surface wave operation
  - ALE system operation is transparent to the method of propagation :
  - remote users connected over sky-wave can automatically be incorporated with those using surface wave propagation
- ALE also provides group calls and net calls

Factors Affecting Network Throughputs

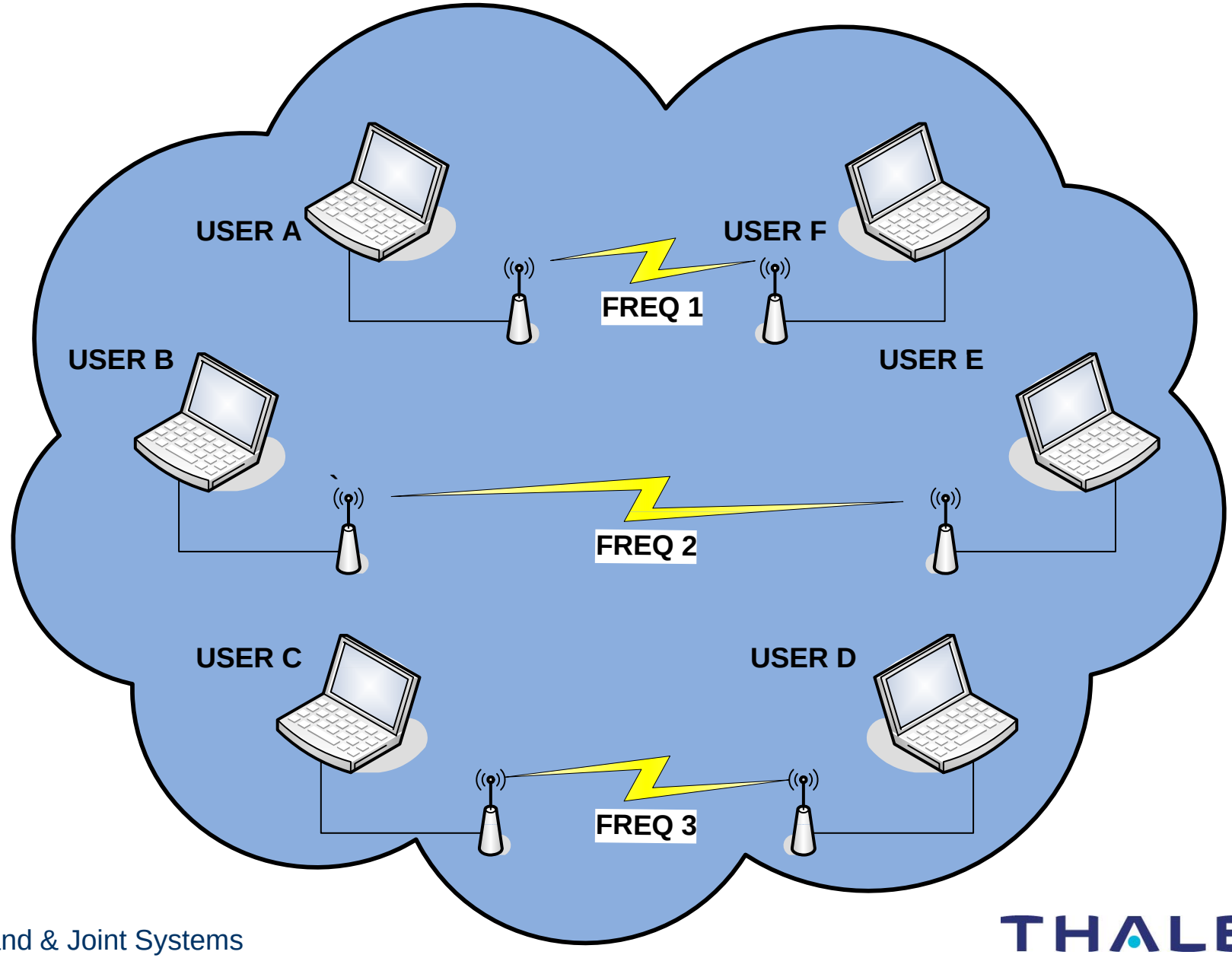
ALE Specific

- ALE linking time
  - The ALE protocol used i.e 2nd / 3rd Generation or other
  - Number of frequencies in the ALE scan set and scan rate – directly affects 2nd Generation ALE linking times
  - Probability of linking on a frequency in the scan set
    - Propagation, time of day & year, Sunspot Number, physical location on the Earth's surface, distance between platforms
  - Type of call : pt-pt, group ,net

Factors common with Token Ring

- Modem latency (interleaver) – tends to reduce throughput
- Equipment / System parameters
  - TX power, Rx sensitivity, Antennas, Local noise levels
- Traffic distribution - smaller transfers have relatively higher overheads

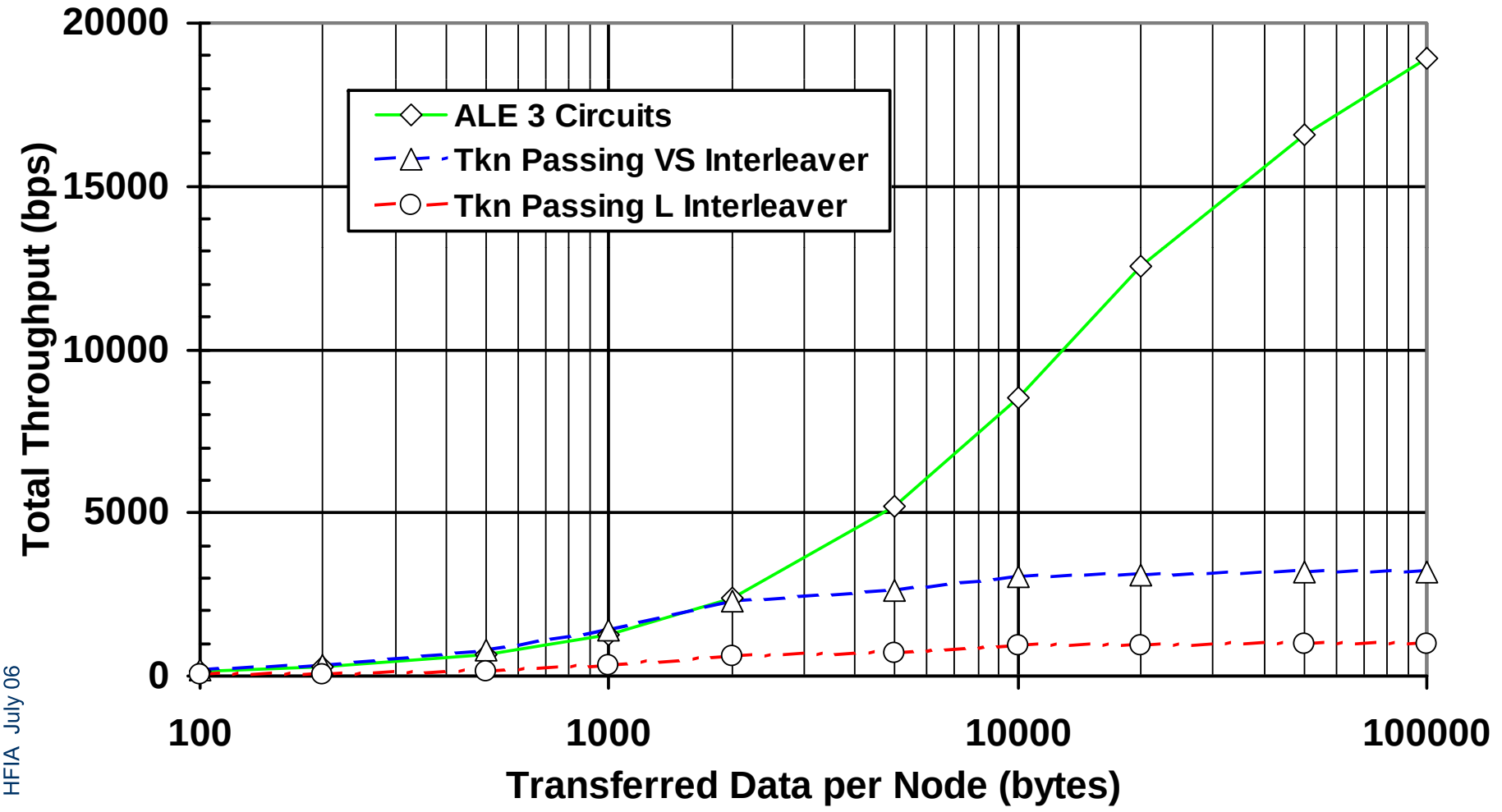
6 Node ALE Network : Three Independent links



6 Node Network ALE / Token Ring : Throughputs

ALE Net : 2 Links at 9600bps and 1 link at 6400 bps

Token Ring Net : common data rate of 6400 bps



HF CHAT- some issues

- A single common frequency can be set up either :
  - Token ring : new STANAG required
  - ALE : no new standard
- COTS IP Chat clients : do they meet the user need?
  - Answer not clear and even if one does which one is chosen ?
- Isn't there a chat type capability in ALE ?
  - Yes in the AMDs
- Is an HF Chat application an expensive application to develop for HF (5066):
  - Not necessarily– a simple version can be based on existing Annex F specs.
- Shouldn't we specify an interoperable HF chat client b*efore we develop new channel access methods to support it ?*

STANAG 5066 V2

- UK HF programmes do not have allowance for extra costs to implement STANAG 5066 V2
  - STANAG V1.2 is primarily event driven with time-outs
  - STANAG V2.0 has more of time driven approach
- If STANAG 5066 v2 requires major redesign of V1.2 stack costs may preclude wide adoption of V2.0
  - particularly if any problems with backward interop with V1.2 implementations
- Interoperability of V2.0 implementations not proven
  - V1.2 not released for ratification until two industrial vendors had proven interoperability - what is the approach for V2.0
- What is the compelling argument ?
  - Unless RTT very long (makes system unusable for Chat) single frequency is vastly less efficient than pt-pt - with ALE
    - We cannot afford to lose b/width at HF
  - Reliability unproven – many obvious configuration problems
  - Primarily designed for single frequency LOS applications
  - Doesn't utilise existing ALE capability

Summary

- Focus on single frequency nets when ALE widely available and not yet properly utilised in many (naval) environments appears premature,
  - especially when required application unclear and significant impact on performance, costs, interoperability
- Difficult to see how a reliable network configuration will be achieved using a single frequency net with variable length messages
  - Chat, Email (5066) with attachments, formal messaging very different from Link 11
- ALE provides a number of advantages for many applications
- ALE can be used to set up a single frequency net if required
- HF will always have a bespoke nature given the limited bandwidth and unique propagation features of HF
  - Purist IP layered approach unlikely to be usable when only ~1 Kbps max raw throughput is available per user e.g. ~ 6 Nodes at 6400bps
- Recommend more focus on the use of proven 2nd Gen ALE and 5066 V1.2 capabilities & possibly a new HF CHAT application .