Next Generation ALE Concepts

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Overview

- History of ALE
- Comparison of 2G and 3G ALE
- How can ALE be improved?
- Summary
- References

History 1980-1985

- First ALE Systems in early 80s
  - Collins Selscan®
  - Harris Autolink®
  - Sunair Scancall®
- Mitre hired by Gov't in 1982 to Investigate interoperability problems and determined:
  - US Gov't could use existing assets much better (SHARES)
  - Gov't needed 2nd Generation ALE standard
- "Mitre Scheme" developed
  - Based on 3 existing systems, plus enhancements
  - Many new features
  - "Stairway to Heaven"

History 1985-1990

- Gov't and industry became highly polarized in 1985
  - USA, FEMA, Harris on Mitre waveform
  - USAF, NCS, Collins on Selscan
- Linking performance testing 1988
- Mitre waveform performed significantly better across all channel conditions
- MIL-STD-188-141A ALE released as a result in Sep 88 [1]
- FED-STD-1045 released in Sep 90[2]

History 1995-2009

- Mid 1990s NATO develops HF House concept
- Key component of HF House was ARCS
- Initial thought is to base improved ALE protocol on robust 75 bps waveform defined in 110A and STANAG 4415 [3]
- Harris develops and implements a burst serial tone waveform on IR&D used for Link Setup
- Harris develops code-combining based ARQ systems
- MIL-STD 188-141B Appendix C defined based on these concepts[4]
- ARCS develops into STANAG 4538 [5]and is based on a variation of these concepts

History – Present State of ALE

- Many mature products conforming to 188-141A(B) ALE (2G) Fielded
  - Virtually all new professional radios have embedded 2G ALE
- A number of manufacturers have invested in 3G technology as defined in STANAG 4538.
  - To date many thousands of radios deployed with users utilizing 3G ALE
- Automated systems use ALE for media access control
- Very few proprietary systems fielded

2G / 3G Comparison

Characteristic	2G ALE	3GALE
Link Time	15.3s -3 character call sign	8.4s (Average values [6]
Link Robustness	0dB(3kHz BW)(0dB PAPR)	-8dB(3kHz BW)(4dB PAPR)
Waveform	8-FSK – 125 sym/s	8-PSK – 2400 sym/s
Main mode of Operation	Asynchronous	Synchronous Asynchronous Supported
Link Protection	Y – Not widely used	Y – Widely used
Channel Evaluation	LQA & Traffic Monitor	LQA & Traffic Monitor
Real Time Channel Evaluation (RTCE)	N	N
Listen Before Transmit	Y	Y
Adaptive / Cognitive	N	N

ALE Attributes

- Linking Time
  - Time to establish radios linked on a propagating frequency
  - Depends on synchronization approach
- Frequency management
  - Establishment of frequency / channel set
  - Can be based on prediction programs or experience
  - Geographical location of stations, required capacity, length of deployment all impact the number of frequencies needed
- Channel selection
  - Selection of frequency channel to use for communication
  - Can be based on prediction
  - Can be based on RTCE
  - Can be based on user communications history
  - Can be based on channel interference – Listen Before Transmit

How can ALE be improved?

- Faster Linking times
  - Decrease overhead, increase capacity
- Frequency Management
  - Employ cognitive radio concepts
  - Dynamically use unused frequencies
  - Improved Listen Before Transmit
- Channel Selection
  - Real Time selection just before use
  - Accurate signal quality estimates
- Wider bandwidth support
  - 6,12,24 KHz channels being defined in 141B

Linking Time

- 2G ALE
  - Employs a fast asynchronous scan coupled with a long link establishment transmission on the desired frequency. The transmission is long enough to capture the scanning receiver and begin the handshake on the desired frequency
- 3G ALE
  - Employs a slower synchronous scan coupled with a short link establishment transmission on the desired frequency. However as the system is synchronous the system must wait for the desired frequency dwell to happen. With a dwell time of 1.35 seconds this delay can have a significant impact.

Linking Time Alternatives

- Faster scan
  - 2G - RC QuickCall
  - 3G - Harris HCMac
  - Moderate improvement
- Parallel Receivers
  - Dedicated receiver for each channel/frequency
  - Link time can be reduced as the system does not need to capture the scanning receiver (2G) or wait for the desired frequency slot to come up
  - Large system / HW impact
  - Significant Improvement

Frequency Management

- Frequency planning usually based on set of assigned frequencies. Planning tools available that allow user to plan a mission and “fill” a deployment of radios with required channel information.
- Missions may be planned significantly prior to deployment

Frequency Management Alternatives

- Fill sets based on Time of day (Night/Day)
- Deterministic pseudo-random allocation of pooled frequencies [7]

- Cognitive radio concepts
  - Modify frequency set in real time
  - Explore unused frequencies based on propagation prediction or between known propagating frequencies
  - Use improved Listen Before Transmit techniques to detect signaling on all channels
  - Frequency set based on assigned + cognitive frequencies
  - Protocol must be modified to announce new cognitive frequencies to the network, preferably in a robust minimal impact manner.
  - Power management considerations
  - Regulatory issues

Channel Selection

- Most ALE systems, both 2G and 3G utilize ranking techniques to maintain a quality metric on each channel / destination.
- Most ALE systems, both 2G and 3G utilize some sounding or Link Quality Analysis (LQA) signaling to occasionally or periodically update these quality metrics
- Previous work has shown that Real Time Channel Evaluation provides performance / capacity gains by performing a quick quality analysis on all channels just prior to use [8][9]
- The Harris Fast ALE System of the early 1990s successfully implemented RTCE and Linking[10]

- Improved Estimation and detection techniques
  - Improved channel quality estimation techniques can be used to provide estimates of SNR, multipath delay spread and Doppler spread using transmitted probe
  - Improved LBT Techniques can be used to monitor frequencies when not in use [11]
  - Performance of these techniques limited by observation time
- Multi-channel probe link establishment
  - Link establishment signaling sent serially or in parallel on multiple frequencies can be used to probe the channel list just before use (RTCE)
  - A parallel receiver structure can be used to minimize synchronization time
  - ALE Link Setup process needs to include identification of selected channel to establish link on

Wider Bandwidth

- Wider bandwidth channels being defined in MIL-STD-188-141C
- Both 2G ALE and 3G ALE are 3kHz SSB systems
- Need to consider how ALE would work in different bandwidths
- Should adaptive bandwidth systems be considered?

Summary

- ALE systems required due to the propagation / interference complexities of HF links
- Many 2G and 3G ALE systems have been successfully deployed
- Opportunities exist for further improvements:
  - Faster linking times
  - Cognitive radio concepts
  - More accurate channel characterization
  - More accurate signal detection
  - Wider Bandwidth systems

References

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