

Extending the Infosphere to Mobile and Embedded Systems

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Agenda

- About AgileDelta
- Motivation
- Military Objectives, Use Cases & Requirements
- Survey of Existing Approaches
- Efficient XML
- Status and Future Work

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About AgileDelta, Inc.

Company: AgileDelta, Inc. is a privately held corporation headquartered in Bellevue, WA. AgileDelta is self funded and has been profitable since 2001.

Mission: To maximize the value of information by getting it to the people that need it, when they need it, where they need it.

Customers: Include leading platform vendors, such as BEA Systems, large enterprises, such as the US Air Force and smaller technology providers.

Team: Thought leaders and industry veterans from Microsoft, Oracle, Cisco, Amazon, Infospace, ...

Military Requirements Background

- Principal Engineer at MITRE researching and devising technologies to address military information interoperability problems for 9 years
 - Before XML
 - Devised and led development of advanced technologies for military information interoperability now fielded across the U.S. and 20+ other countries
 - Devised first schema-based compression scheme for structured text messages (KBC)
 - Real-time, on-site analysis of military information sharing processes, patterns and problems in live Joint and Allied exercises and operations (OV93, AP94, UE95, NL96)
 - U.S. delegate to NATO developing and advocating U.S. requirements and positions on information interoperability processes, architectures and technologies
 - After XML
 - Kick started and led several initiatives to migrate U.S. and coalition partners to XML to leverage cost and interoperability benefits of competitive XML market
 - MITRE W3C representative sharing expertise toward rapid development of low cost, high quality, rapidly evolving COTS solutions to military interoperability problems
- Based on our expertise with XML, data compression and military interoperability, the U.S. Air Force selected us to investigate, characterize, address and advocate military requirements for binary XML.

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The Problem

TAXI XML is Resource Intensive

- Bandwidth requirements
- Main memory requirements
- Secondary storage requirements
- Processor requirements
- Battery requirements
- Code complexity and footprint (e.g., namespaces, schema, object model)
- Effectively limits the number and type of systems that can produce and consume XML information
 - Creates an interoperability rift between fixed, mobile, embedded and real-time systems
 - Prohibits mobile and embedded systems from leveraging the economic and interoperability benefits of XML

SPACOM

OTM

XML

WME

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Military Objectives

- Bridge gap between command centers, aircraft, ships, ground forces, satellites, sensors, UAVs, etc.
- Reduce bandwidth requirements for XML data
- Reduce cost of development, procurement and maintenance by leveraging widespread commercial technologies
- Increase tempo of evolution and technology insertion by leveraging dynamics of competitive mass market
- Match speed and performance of existing hand optimized solutions
- Support implementation on existing mobile and embedded platforms (some with limited processors, memory, storage & battery)
- Invest in a single solution that addresses the broad range of DoD and coalition use cases instead of buying several non-interoperable solutions

Military Use Cases

- Most important and immediate is C2 interoperability, including
 - Very small and very large data-centric messages
 - Messages with large amounts of both data and text
 - Broadcast and receive only systems
 - Systems with very capable and very limited processors, memories, storage and batteries
 - Systems using several different versions of the same schema
 - Operational requirements that evolve faster than schemas
 - Special cases, such as low-detection, short duration, one-way comms
- Additional important use cases include:
 - Efficient web services
 - Middleware replacement
 - Massive documents (e.g., aircraft maintenance manuals)
 - 3D visualization, modeling, simulation & replay
 - Mobile web applications over narrowband wireless links

The DoD and its coalition partners are massive enterprises with diverse uses for XML

Military Requirements

- Must produce compact encodings for
 - Large and small documents
 - Data and text centric documents
 - Documents with and without schemas
- Must support high and low fidelity (logical & physical) encodings
- Must be directly readable and writable
- Must support streaming
- Must support query results and document fragments
- Must support systems with low memory and processing capabilities
- Must be resilient to schema evolution
- Must be resilient to schema deviations
- Must support pluggable encoder extensions
- Must continue to work seamlessly with existing technology stack (signatures, encryption, queries, schemas, transforms, ...)

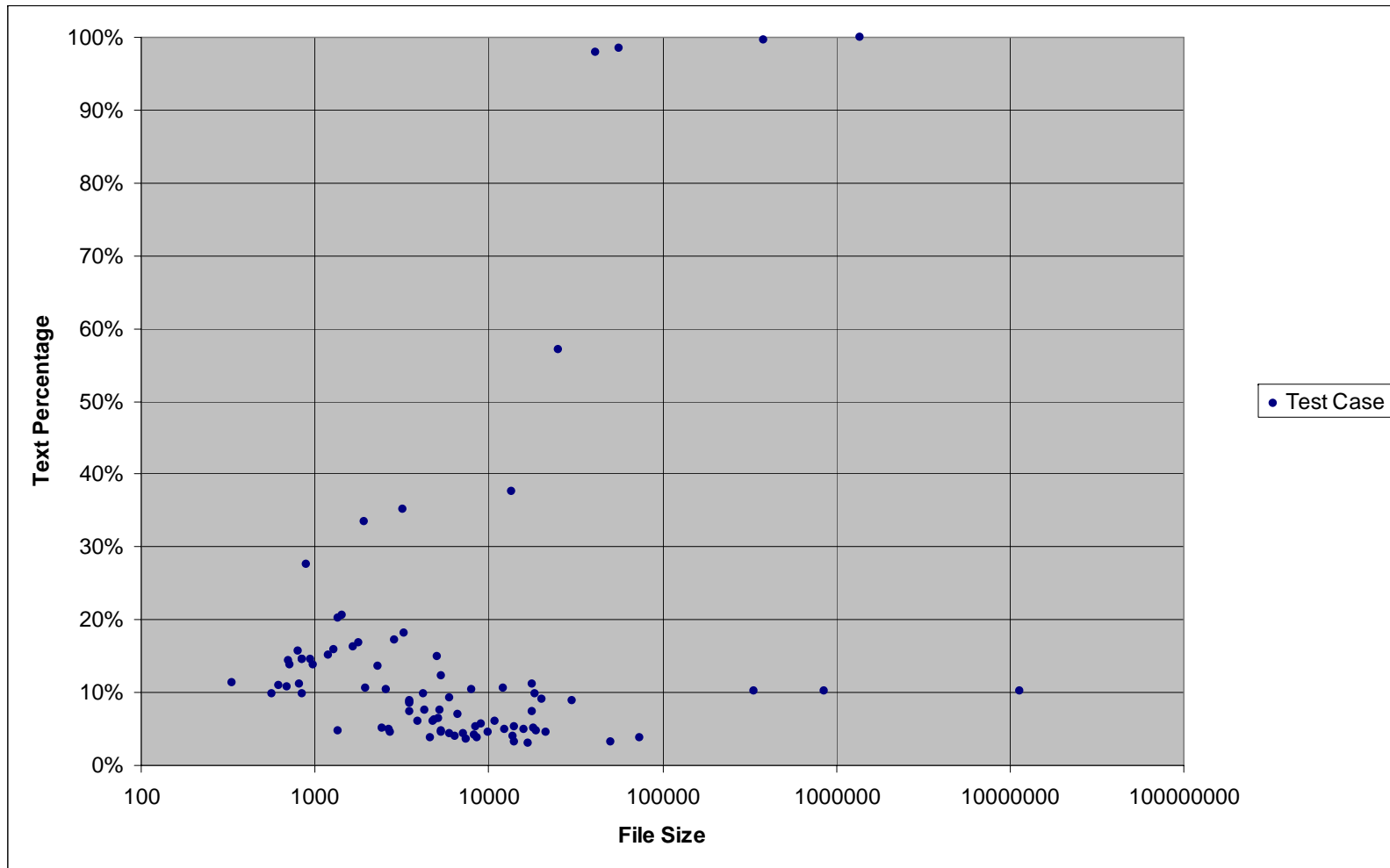
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- **Survey of Existing Approaches**
- Efficient XML
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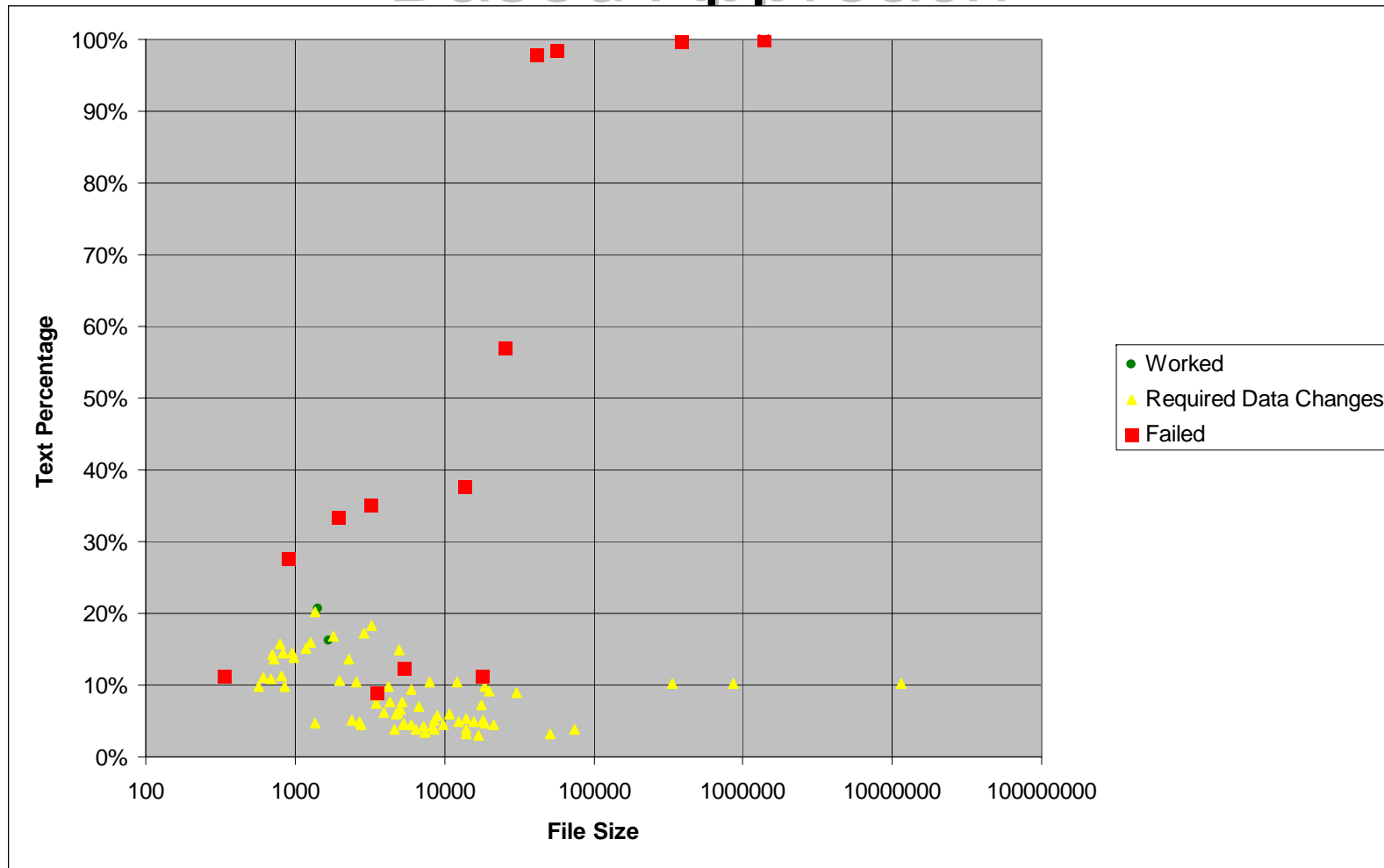
Survey of Existing Approaches

- Many approaches have emerged from vertical industries and research
- Here we'll focus the more popular and promising ones
 - **ASN.1 PER:** Mature and widely used in the telecommunications industry
 - **MPEG-7 BiM:** Relatively new encoding for associating metadata with video
 - **WAP WB-XML:** Widely used for sending small web pages to mobile devices
 - **Millau:** Research proposal for more efficient variant of WAP WB-XML (below)
 - **XMill:** Early AT&T research effort. No longer active, but provides an interesting benchmark for performance on large documents.
 - **ZIP:** popular compression method used on desktop systems
- Completed requirements analysis based on available specifications
- Tested available implementations against a suite of over 450 Schemas and associated instance documents
 - Covering a wide range of U.S. and coalition air, maritime, ground and intelligence use cases as well as several commercial use cases
 - 380 test cases were generated from Schemas using automatically generated mock data designed to test full feature coverage
 - 72 use cases were completed by specialists using more realistic data

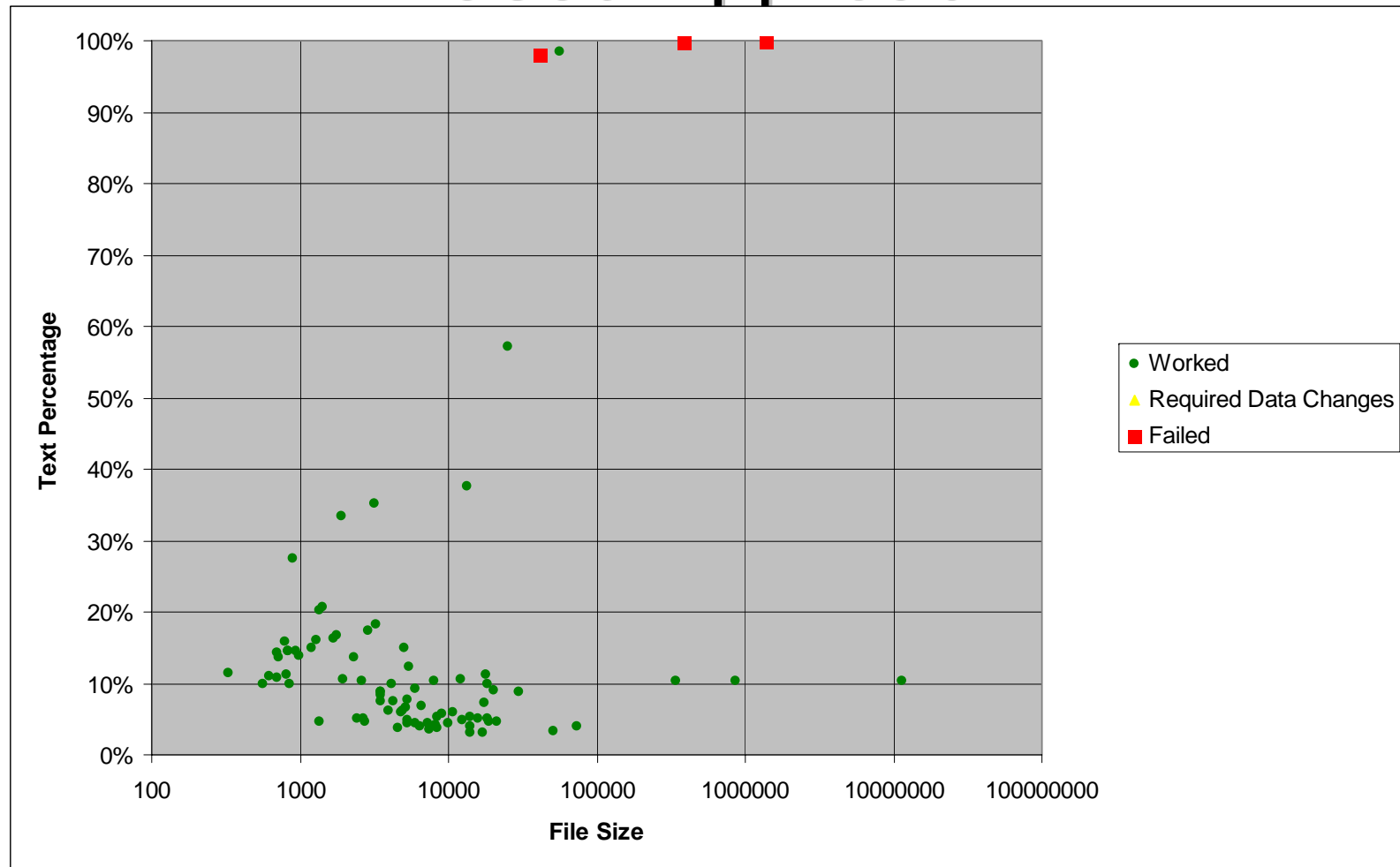
Test Case Characterization



Test Results for Leading Schema-Based Approach

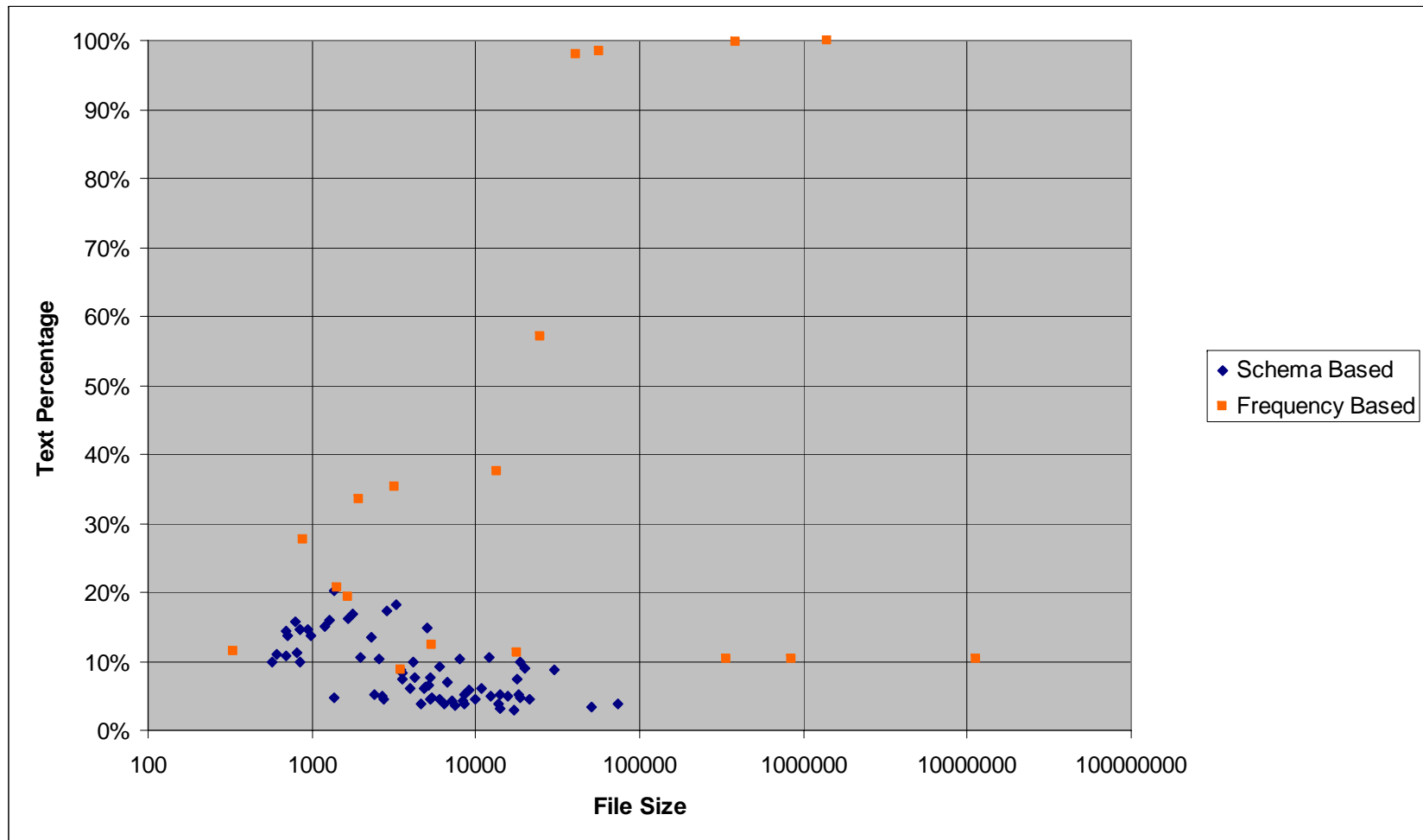


Test Results for Leading Frequency-Based Approach



Frequency vs. Schema Analysis

Which works best?



Requirements Coverage

Requirement	Approach 1	Approach 2	Approach 3	Approach 4	Approach 5	ZIP
Large & small documents	Red	Yellow	Red	Yellow	Red	Red
Data & document centric	Red	Red	Yellow	Yellow	Red	Red
Schema & schema-less	Yellow	Red	Yellow	Red	Red	Red
High & low fidelity	Red	Red	Green	Red	Red	Red
Directly read and writable	Green	Green	Red	Green	Green	Red
Streaming	Green	Yellow	Red	Green	Green	Red
Encoding query results	Red	Green	Yellow	Red	Red	Yellow
Low memory and processing requirements	Green	Green	Red	Green	Green	Red
Schema evolution	Red	Green	Green	Red	Red	Green
Schema variations	Red	Red	Green	Red	Red	Green
Pluggable encoders	Red	Red	Yellow	Red	Red	Red

Every requirement was met by some approach, but no approach met every requirement

Observations and Questions

- Observations
 - Many of the requirements seem at tension
 - Most existing solutions seem optimized for a specific set of requirements and specific types of XML data
- Questions
 - Is it possible for a single solution to address all military use cases and requirements?
 - Will it be a jack of all trades, but master of none?

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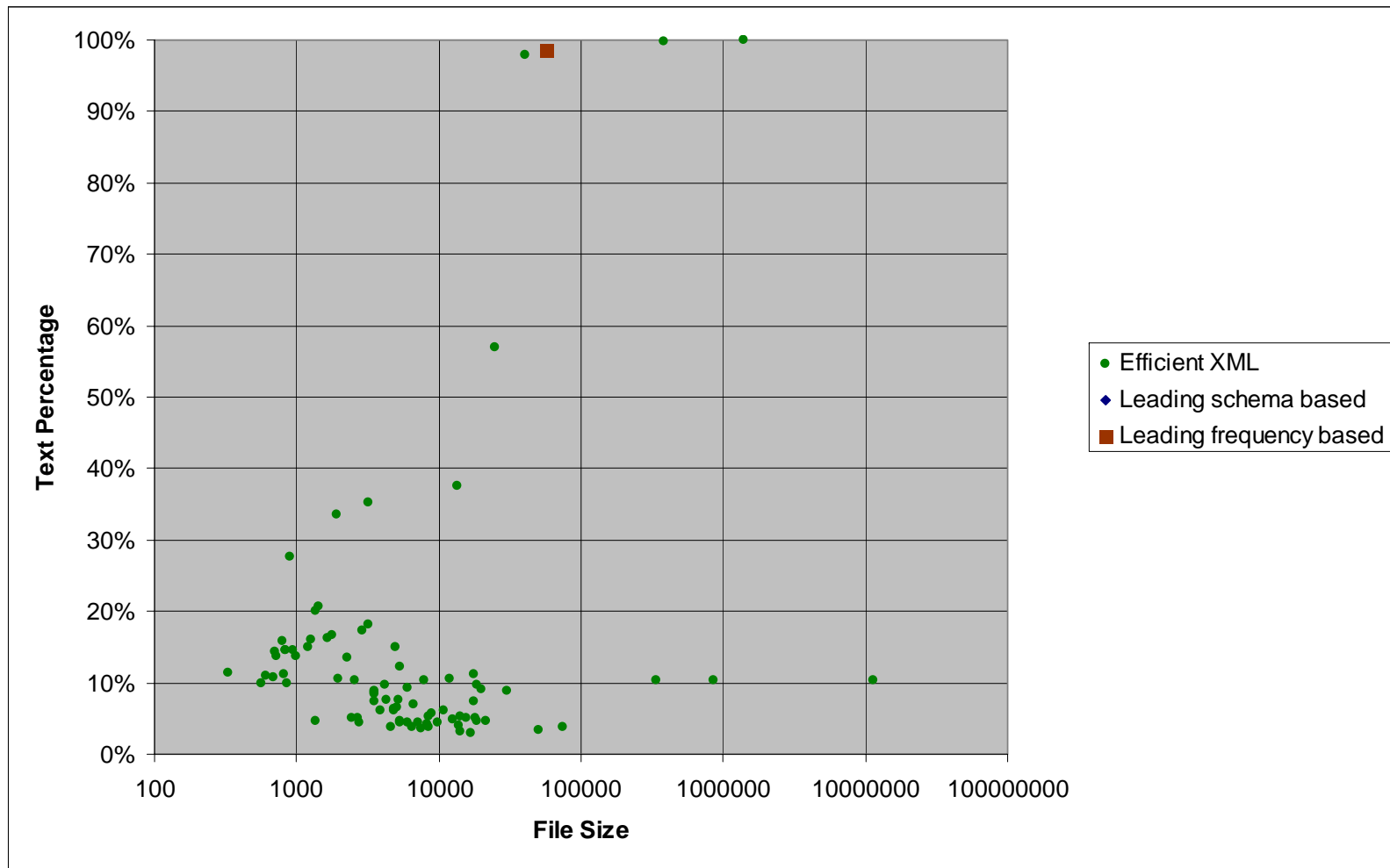
Efficient XML

- We set out to develop a uniquely efficient XML encoding with the following design objectives
 - Satisfy the broadest range of XML use cases and requirements (military and commercial)
 - Avoid optimizing for a specific set of use cases or scenarios
 - Compete with schema-based approaches on small, data centric files
 - Compete with frequency-based approaches on large, document centric files in scenarios where frequency-analysis is an option (i.e., systems with more memory and lesser streaming requirements)
- The resulting technology is called Efficient XML
 - Unifies schema-analysis and frequency analysis techniques through their common roots in information theory
 - Borrows best-of-breed encoding techniques from both schema-based and frequency-based approaches
 - Is tunable for different operating environments
 - Low analysis: for environments with small files, limited resources and/or strict streaming requirements
 - High analysis: for environments with larger files, more resources and lesser streaming requirements

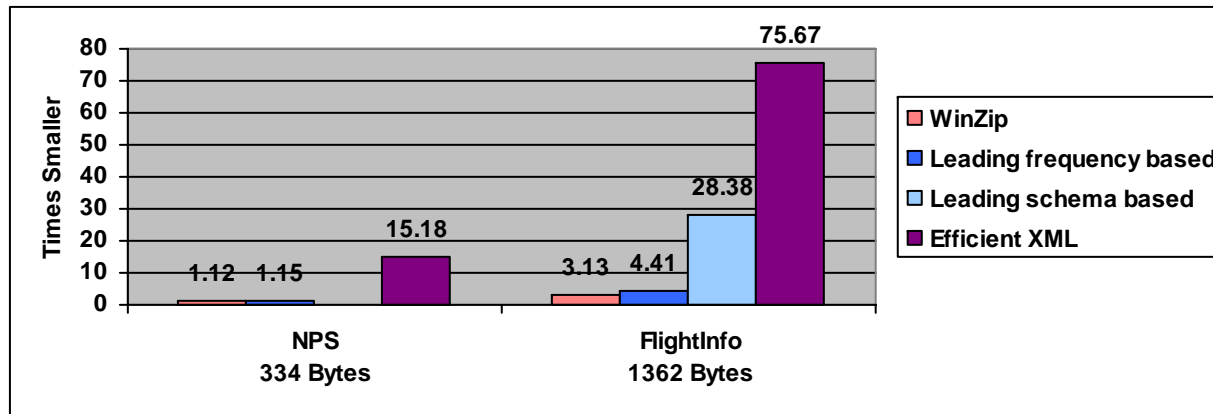
Efficient XML Satisfies All Requirements

Requirement	Approach 1	Approach 2	Approach 3	Approach 4	Approach 5	ZIP	Efficient XML
Large & small documents	Red	Yellow	Red	Yellow	Red	Red	Green
Data & document centric	Red	Red	Yellow	Yellow	Red	Red	Green
Schema & schema-less	Yellow	Red	Yellow	Red	Red	Red	Green
High & low fidelity	Red	Red	Green	Red	Red	Red	Green
Directly read and writable	Green	Green	Red	Green	Green	Red	Green
Streaming	Green	Yellow	Red	Green	Green	Red	Green
Encoding query results	Red	Green	Yellow	Red	Red	Yellow	Green
Low memory and processing requirements	Green	Green	Red	Green	Green	Red	Green
Schema evolution	Red	Green	Green	Red	Red	Green	Green
Schema variations	Red	Red	Green	Red	Red	Green	Green
Pluggable encoders	Red	Red	Yellow	Red	Red	Red	Green

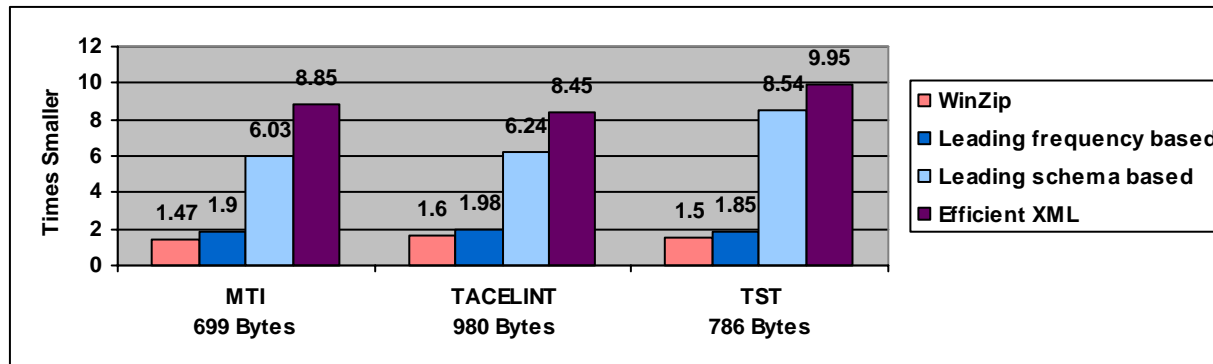
Efficient XML Works Best for Most Cases



Efficient XML on Small Messages

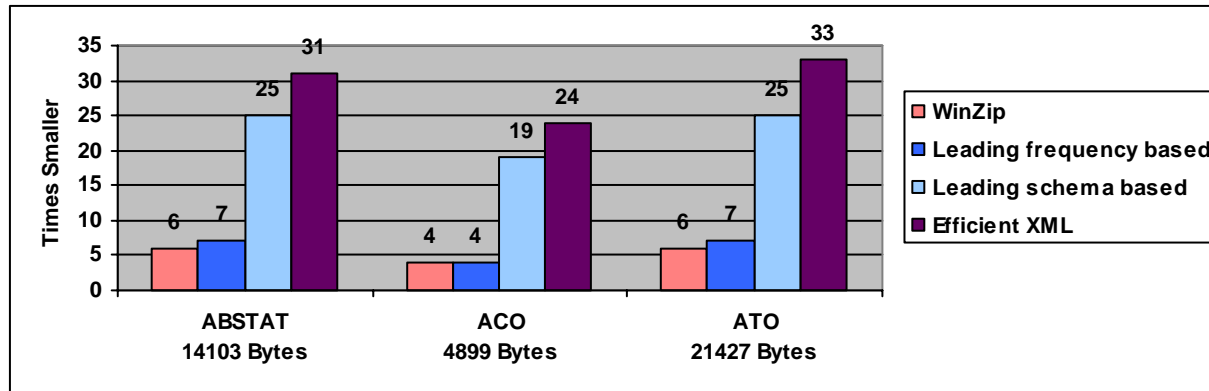


Small, strongly typed messages show potential of Efficient XML

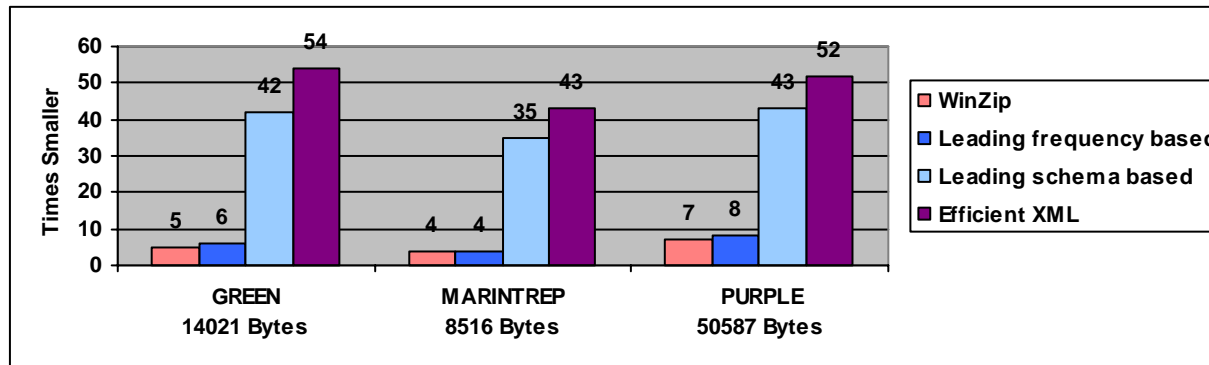


Small, loosely typed JBI Intelligence Metadata

Efficient XML on Medium Messages

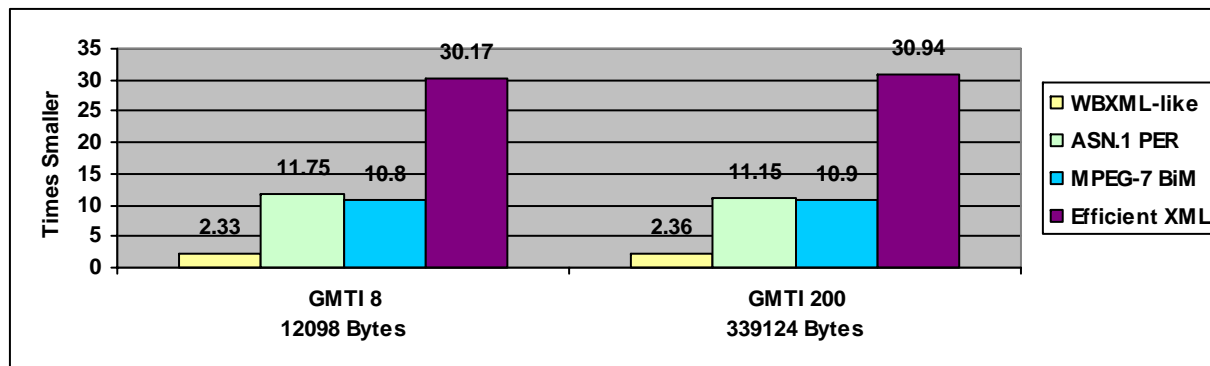


Medium sized XML-MTF air operations messages

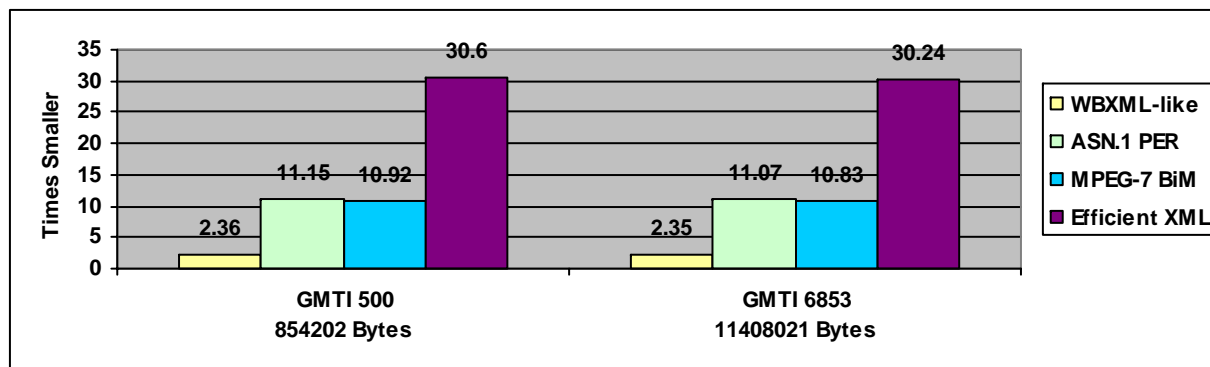


Medium sized XML-MTF maritime operations messages

Low Analysis Efficient XML vs. Schema Based Approaches



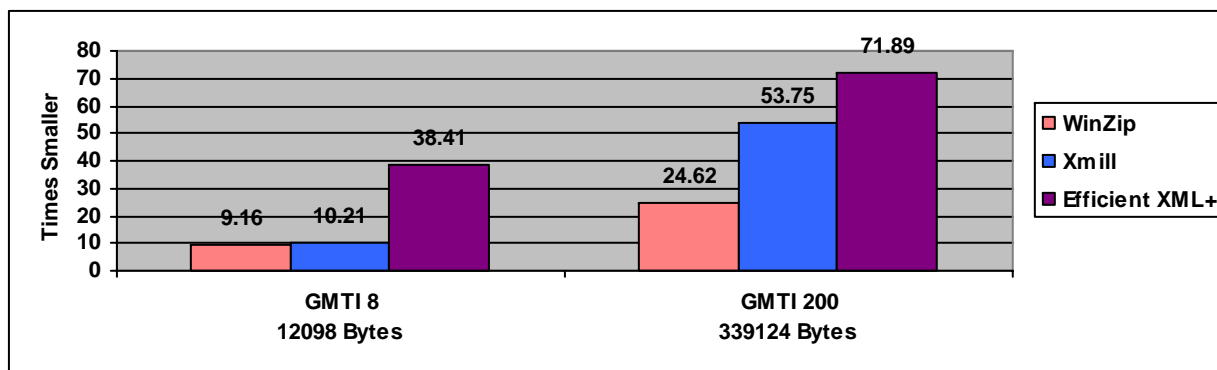
8 and 200 tracks of Ground Moving Target Indicators from JSTARS



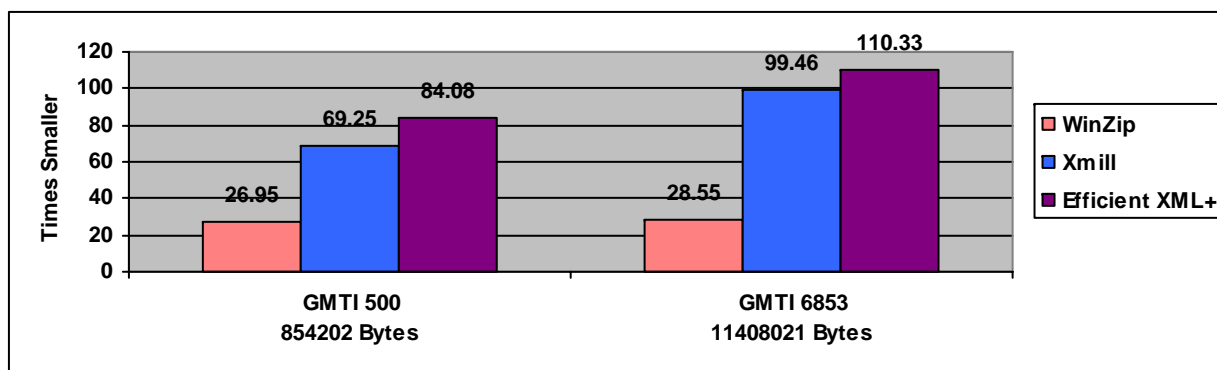
500 and 6853 tracks of Ground Moving Target Indicators from JSTARS

Performance data taken from MITRE publication *XML Sizing and Compression Study for Military Data*

High Analysis Efficient XML vs. Frequency Based Approaches



8 and 200 tracks of Ground Moving Target Indicators from JSTARS



500 and 6853 tracks of Ground Moving Target Indicators from JSTARS

Performance data taken from MITRE publication *XML Sizing and Compression Study for Military Data*

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Status and Future Work

- We need a global industry standard for Efficient XML!
 - We are currently working toward this goal as founding members of the W3C XML Binary Characterization Working Group
 - We submitted a proposal to the W3C advocating a global standard that satisfies the broad range of military and commercial requirements
 - We actively participated in the workshop held by the W3C to gauge interest on the topic in September 2003
 - We plan to contribute the Efficient XML format specifications to the W3C when they begin to develop a standard
 - However, we do not expect a completed W3C standard before 2007!
- In the mean time,
 - The USAF has contracted AgileDelta to deliver Efficient XML for widespread use across the DoD
 - Successive versions of Efficient XML will track the eventual W3C standard
 - We continue to devise additional improvements and want to ensure we are addressing and advocating your requirements. Contact us to:
 - Share your use cases, requirements and test data!
 - Participate in exercises and demonstrations
 - Begin integrating Efficient XML into your systems

Questions and Discussion

For additional information see

<http://www.agiledelta.com/EfficientXMLEncoding.htm>