WindSpring

Relevance Matters ..

DMT - Edit in Place

Enabling the delivery of relevant and reliable digital map data and content

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Objectives

The objectives of this White Paper are:

- Describe the nature of compressed data in PND devices
- Summarize the problems inherent in current compression methods
- Outline the solutions that WindSpring's DMT can provide.

Introduction

WindSpring SDK provides an elegant software-based solution for the data challenges presented by the next generation of mobile device data storage applications. WindSpring SDK utilizes WindSpring's patented Data Miniaturization Technology (DMT) to transform navigation data formats into WindSpring's new Micro Data Format (MDF).

MDF is ideally suited for accessing and editing navigation data used in on-line and off-line GPS navigation. Here, the large amounts of update data often preclude timely system upgrades resulting in inaccurate navigation and POI data and poor user experience.

DMT can provide the user with a richer experience by reducing the time to send update information, providing a mechanism to update compressed stored data, and enabling the application of on-line real-time updates to stored datasets.

Navigation Data

Device Properties

Most mobile navigation devices, such as SmartPhones, have limitations on the amount of data that can be permanently stored on the devices. These limitations are driven both by target market price and current technology resources.

Cost considerations dominate the amount of internal memory, the quality of the display and the method used to connect to on-line real-time services.
Table 1 below shows typical device characteristics for popular low-end PND devices.

#1	Garmin Nuvi 350 GPS Receiver 3.87" W x 2.91" H x 0.87" D Size • 5.1 oz Weight • 6 million Points of Interest • MP3 Audio • 8 hour Battery Life • 3.5 in Display • SD memory card slot Media • optional FM Receiver • Turn by Turn Voice Guidance
#2	Garmin Nuvi 660 GPS Receiver 4.9" W x 2.9" H x 0.9" D Size • 6.2 oz Weight • 6 million Points of Interest • MP3 Audio • bluetooth Capable • 7 hour Battery Life • 4.3 in Display • SD memory card slot Media • FM Receiver • Turn by Turn Voice Guidance

Table 1 Typical Device Characteristics

Note that key characteristics quoted include point of interest (POI) data, memory expansion and on-line connectivity.

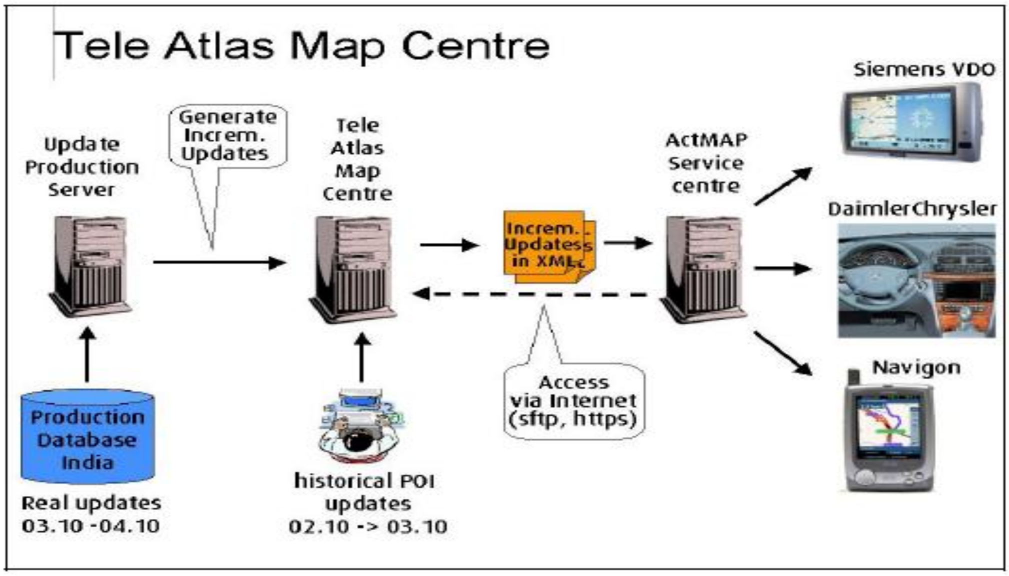
Data Characteristics

The data used in portable navigation devices is usually created at a server, compressed or compacted, and stored in the mobile device. Storage usually is a mix of fixed in-device flash memory storage and memory card slots. In-dash devices usually use DVD or Hard Disk (HDD) based storage.

Navigation data and system updates provided by the manufacturer are usually web or DVD based.

Real-time data updates, such as traffic or road works, are provided over the air by carriers on either FM radio or mobile phone networks.

Recently, a project was conducted by the European Commission DG Information Society to develop a standard solution for incremental updates of in-vehicle map databases. The goals were to enable advanced navigation and advanced driver assistance systems (ADAS).



Key results from the project included

- The large installed database need frequent updates
- Road network changes @ 15%/year, POIs up to 50%/year
- Current map update cycle is 3, 6, or 12 months
- Most maps are out of date
- Subscription-based services are dependent on accurate and up-to-date road & POI data
- Advanced Driver Assistance Systems will demand highly accurate and up-to-date maps as well as data on road conditions, traffic patterns etc
- Next generation in-vehicle systems are hard drive based which require new update methodology

Existing Format Limitations

The way navigation data is stored, updates and maintained significantly affects the user experience and benefits. Key issues include the frequency of updates, the interface to real-time data such as traffic and the ability to dynamically edit routing and navigation information.

Point of interest information, including real-time pricing is also important for user satisfaction.

Current map data formats usually preclude dynamic updates. To achieve maximum data storage in the constrained environments of PNDs, data is usually compacted or compressed. This is done using special encoding methods that are usually vendor dependant and proprietary.

However, map updates are difficult to apply to compressed or compacted data. Small changes to the dataset are inhibited by these multiple vendor formats. Proprietary, compressed formats cannot be easily edited without major downloads and replacement of the entire data set.

Uncompressed formats require too much storage space and are slow to update.

In online systems, large data volumes for POIs, traffic and parking information lead to increased cost and delays.

Navigation Device Performance Constraints

On-Board Navigation Application Software for PNDs

PNDs generally have sufficient processing power and memory to ensure fast access to map, POI and address look-up data. The key performance limitations for these devices are driven by external storage capacity limitations and external storage cost.

On-Board Navigation Application Software for In-Dash

Integrated in-dash devices generally have sufficient processing power and memory to ensure fast access to map, POI and address look-up data. The key performance limitations for these devices are driven by DVD capacity limitations, HDD (Hard disk) mechanical constraints and external update implementation costs.

On-Board Navigation (SmartPhones)

Only a limited percentage of Smartphone devices are able to process a wide range of web services, including mobile GPS navigation. These devices support Connected Limited Device Configuration variant of J2ME, but are not generally powerful enough to support Connected Device Configuration (CDC) or Java 2 Standard Edition.

Off-board navigation applications (SmartPhones and PDAs)

The key performance problem experienced by users of wireless GPS navigation services is the time taken for map data to be delivered to the mobile device, each time a map is required to be updated (via "zoom", "pan" or location update).

Map delivery time components include call connection time, position triangulation time, map data integration, map compression, map server throughput limitations, and client connection time.

Application developers and service providers typically try to minimize these collective delays with the following strategies:

- Download of wider area maps at the first download, minimizing call connection time, but further increasing initial map transmission time and device storage requirements.
- Simplification of map data to reduce its size.
- "Tiling" and pre-compression of map data to enable caching of compressed map files (for zoom and scroll) at the client.

In spite of these improvements, map delivery times continue to exceed 8-10 seconds for off-board map services. Subscriber adoption, usage and price for wireless GPS navigation applications and services will continue to be impacted. The same system bottlenecks that drive poor map delivery performance also lead to increased map delivery costs for both navigation service providers and subscribers.

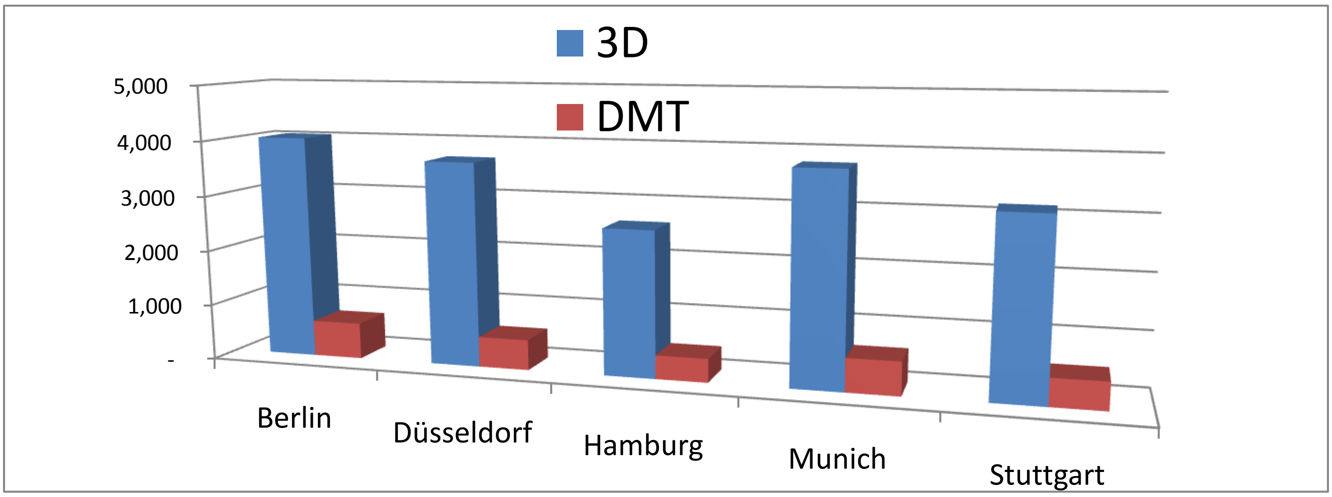
External Memory Cost

While the cost of high-capacity Flash card storage is declining rapidly, high-footprint maps and associated POI and address databases are placing increasing demands on the available external memory. These lead to significant Bill of Materials (BOM) costs for the vendor. The cost of storage is still a significant percentage of the application vendor's gross margin.

Use Case: VRML 3D City data

In a recent test on 3D VRML data from TeleAtlas, DMT achieved an average of 84% compression over five European cities.

The most important issue was that these 3D maps were approaching 4GB EACH.



Edit in Place

Strategies

Current on-line navigation map services are implemented with a mixture of web services, XML, and JavaScript. These technologies can be delivered in real-time to connected devices such as PNDs In-dash devices and Smartphones.

Connections are provided using phones (GPRS, HSDPA or other wireless) or Radio (RDS/TMC, Sirius).

A connected user will typically define the services required which may include traffic, pricing, parking updates etc. This information is usually subscription based plus some connectivity cost.

Typically the operational sequence would be:

1. Download the update or real-time information
2. Expand compressed data to internal memory
3. Adjust navigation/LBS information based on the downloaded data

It is important to understand the internal resources that are required:

1. Communications buffer memory is required to buffer the compressed information
2. Information is then decompressed into another region of memory

3. **For an update**, the information must then be verified before it is used to replace the existing stored navigation data
4. Finally, the stored information is deleted and replaced with the downloaded dataset.

5. **For an edit**, the changed information must be verified
6. The stored information is then de-compacted, edited and re-compacted before being stored back as navigation data

7. **For real-time data,** such as parking or traffic, the downloaded data must be stored
8. This data must then be scanned whenever it is likely to affect either routing or LBS decision making.

Issue	Standard Method	DMT Method
Download	Download data to buffer Decompress to temporary storage	Download edit-in-place changes for DMT data
Update	Verify information Delete entire stored information Copy downloaded information to navigation memory	Verify data Apply edits to stored DMT-format navigation data
Edit	Verify information De-compact relevant stored information to temporary storage Apply edits to navigation data Re-compact and store navigation data	Verify data Apply edits to stored DMT-format navigation data
Real-time data	Verify information Copy downloaded information to LBS memory For each route or navigation event, check LBS memory for additional information	(LBS information is integrated into the navigation memory) Verify data Apply edits to stored DMT-format navigation data
Advantage	By applying proprietary compaction methods, navigation data size can be reduced to the minimum data footprint.	Updates and edits can be applied directly to the on-device data Real-time information can be handled more effectively

DMT Implementation

DMT is a software only process that transforms the original navigation data into the Micro Data Format_(MDF). This MDF is an exact representation of the original data stored using WindSpring's Data Miniaturization Technology. This format allows high-speed seek, search, edit and access of the encoded data while stored in the compressed state.

The key steps required for implementation are:

- Analysis of the navigation data set using the DMT analysis software.
- Optimization for specific speed, file size reduction requirements, and device storage space constraints
- Integration of DMT APIs into the existing application.

Original mapping data is analyzed and then encoded into the MDF format. This analysis, optimization and encoding is done using a range of tools provided by WindSpring.

These include:

- DMT CODEC executables and libraries
- Graphical User Interface (DTTGUI) for manual data analysis
- Test and analysis tools for Codec optimization for automated data analysis
- Sample application programs showing integration of APIs
- Set-up and API documentation

Integration of the WindSpring Codec may then be achieved using the file interface, the stream interface, or via DMT APIs. Implementation of DMT on embedded ARM devices have been achieved in times as short as one week.

DMT Benefits for Navigation Systems

WindSpring's DMT may be applied to a large range of navigation data formats, including:

- Text: ASCII, HTML, XML
- Image: BMP, PNG, TIF, geo-TIF, GIF
- Vector Graphics: SVG, SVG-mini, CMG

The specific benefits of WindSpring DMT to wireless GPS navigation service providers, application developers and subscribers are:

- Reduced mobile storage cost
- Increased navigation application data capacity and functionality
- Reduced data transmission time and cost
- Improved map quality

DMT Performance

The key drivers of miniaturization performance for map and other data formats are:

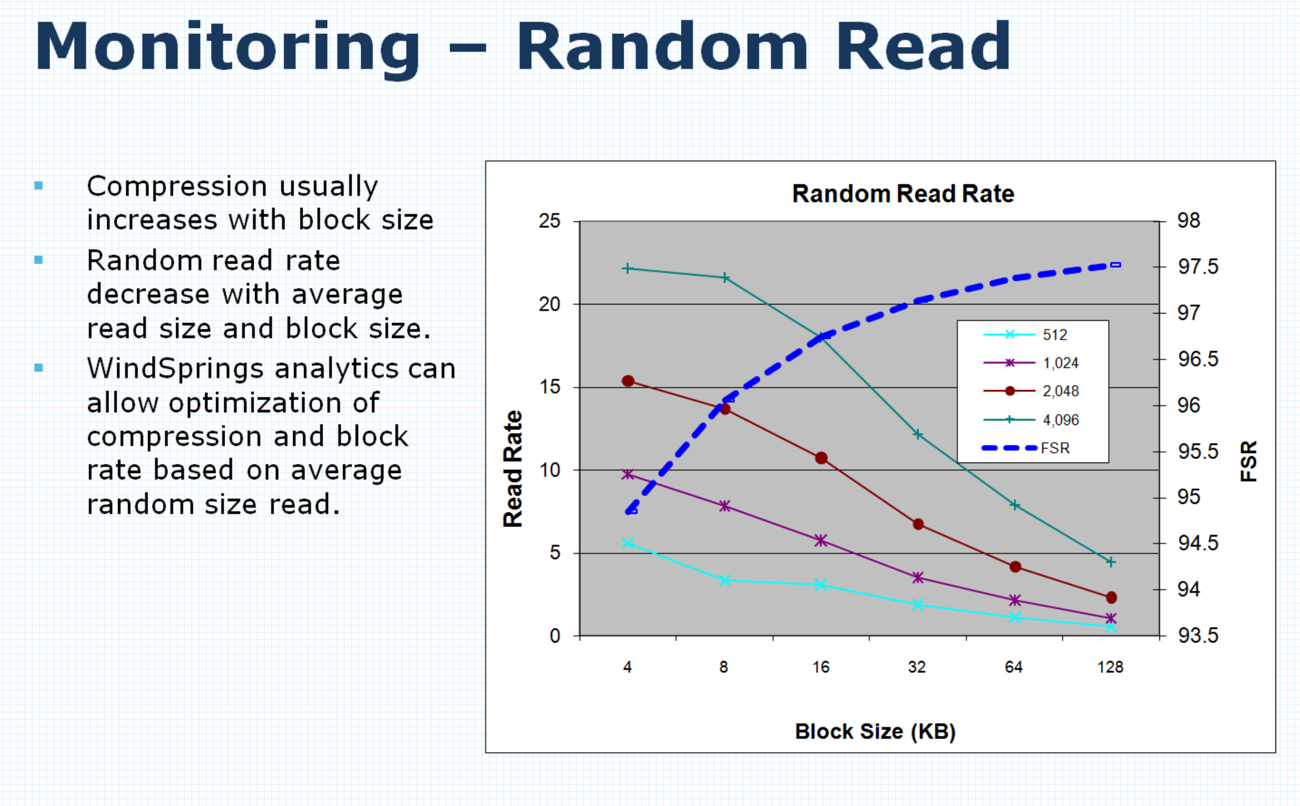
- **Data Type.** Application data that is highly structured (e.g. text, XML, HTML, BMP, Database files) leads to the highest compression performance using DMT. In contrast, compressed file formats (e.g. PNG, GIF) exhibit the lowest performance.
- **Data Size.** For each data format, larger input data sets contain larger proportions of repeating sequences, and therefore exhibit the highest performance.

As illustrated in the tables, WindSpring DMT typically achieves FSR's of between 60% and 80% for text-based data formats, and between 30% and 85% reduction for navigation data.

Text Data Types	Input Data Size (Mb)	Achieved File Size Reduction (%)	Compression Ratio
Text	2.2 Mb	62.6%	2.68
POI	111Mb	74.5%	3.92
XML	65 Kb	79.0%	4.75
WAV	105 Kb	41.1%	1.70

Typical Mapping Data Types	Input Data Size (Mb)	Achieved File Size Reduction (%)	Compression Ratio
Kiwi-W	8.3 GB	41.4%	1.70
deCarta (Rich Map Format)	190 Mb	49.6%	1.98
ESRI (DBF, SHP, SHX, DAT, ID, IND, MAP, MBX, TAB, WOR, PDF)	282 Kb	72.4%	3.62
TeleAtlas (DBF, PRJ, SHP, SHX)	231 Kb	84.2%	6.33

DMT has the potential to improve the performance of navigation systems dependant on the routing engine. Typically, DMT has no knowledge of the routing engine. In recent blind tests on a PND routing engine, DMT achieved between 5 and 10% performance increase over several navigation routes.



DMT was able not only to reduce the size of the data but was also able to reduce the route calculation time. While this is vendor and routing software specific, it is an inherent property of the technology.

Summary

Future Navigation Data Trends

Updates from major vendors are using technologies based on AJAX and XML. If the "Maps will be free, Routing will be free" mantra is true, then accuracy on devices will become essential when competing with technologies based on Google and Yahoo Map-servers.

In connected maps and services, faster tiled image handling, more XML based storage and faster XML database queries are essential. Additional requirements include logging and auditing as well as compliance policies. Enhanced security options will soon be important for two-way communication and navigation data updates.

DMT delivers relevance

The frequency and timing of updates to navigation and LBS data is critical to the user. Since the device is being used as a real-time navigation aid, the changes to the navigation data should be frequent. These updates should be requested and received transparently without further user interaction and without interruption of the navigation.

This can only be achieved in an on-line environment when the communications channel is optimum. The time taken to transmit and receive data, the size of that data and the time to display are issues that drive user acceptance and acceptable performance.

DMT excels in storing data in an editable format. Its features are tuned to both XML and AJAX technologies.

DMT Products

A number of WindSpring products have been developed based on the DMT architecture.

The WindSpring SDK incorporates the following products:

- Encoder, decoder and seed modules
- Development Graphical User Interface (GUI)
- Sample interface access programs and technical documentation
- APIs
- Optimization toolset

The optimization toolset enables optimum parameters to be discovered for particular application data characteristics.

The WindSpring SDK is available for the following server and client operating systems:

- Windows XP
- Pocket PC 5.0, Pocket PC 2003, (Windows CE 4.2)
- Linux
- JAVA and J2ME
- uITRON (custom installation with NRE)

Further Questions

The effect of DMT in Personal Navigation Device display applications is significant. By reducing data latency and network cost, DMT promises to significantly improve subscriber adoption, usage and price, and materially increase revenue potential for a large range of applications and services.

If you would like to obtain further information on DMT or the MDF data format for your existing services or products, or if you would like to evaluate the WindSpring SDK, please contact WindSpring, Inc. at
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