Transducer Mark-up Language

Summary:

Transducer Markup Language (TML) is an Air Force and National Geospatial-Intelligence Agency sponsored development to standardize a way to exchange raw or pre-processed sensor data. Coordination of TML has begun with the OGC. TML will suite the OGC sensor web enablement standards and services. A transducer is either a receiver (i.e. sensor) or a transmitter. TML will facilitate the interoperability and fusion of transducer data. TML exchanges both data and metadata in the same or separate packages. The data is formatted in a natural transducer format requiring little or no pre-processing. The metadata is a consistent set of data elements that can describe how to process the associated data from any sensor to a TML enabled processor. The metadata describes everything an engineer needs to know about the data, such as: data content and structure, transducer characteristics, transducer geometry model, transducer inter-relationships. TML is currently being extended to characterize coherent radar data.

Technology:

Traditionally, sensor data is exchanged using formats, and characterized with models, unique to a particular class, modality, or domain of sensors. When it becomes necessary to acquire process and fuse data from different sensor systems, it is favorable to have a seamless exchange, process and fusion processes. TML is a language which will enable the seamless communication of digital transducer data between transducers and processor. In particular TML was designed to facilitate interoperability of sensors and sensor processors, fusion of heterogeneous sensor data, and the accurate and precise capture of sensor data. Based on XML technology, TML is a sensor data exchange language that allows for the fusion of data at levels not presently achievable (i.e. upstream data). It defines a means to capture and describe streaming transducer data for the purpose of exchanging and processing raw & processed data from disparate transducers. TML facilitates the fusion and interoperability of intelligence and/or information along three key elements of the TPPU chain; namely Post, Processing, and Use, through the concept of information "Discover" and "Pull" in a web/network-enabled environment. Because TML is a domain independent language (i.e. can be used for any application that requires the exchange of sensor data, e.g. environmental, image or signals surveillance and reconnaissance, medical imaging, factory automation, etc), it facilitates the sharing of sensor data across various domains.

Communication of sensor data requires the exchange of the sensor data as well as the metadata to describe the sensor data. With TML, the set of metadata is consistent for any sensor, and shall be consistent for undeveloped sensors. In addition to the common classes of military sensors (e.g. imaging sensors), TML can be used to communicate data from other remote and/or in situ sensors (EO, IR, MSI, HSI, SAR, magnetic, GPS, IMU, Sonar, ESM, UGS, geologic, climate, environmental, position, temperature, force, sound etcetera). This would enable a processor to search, discover, subscribe, and process relevant data from any sensor which may be able to assist in the solution of any intelligence problem. Many standard sensor formats today are designed to handle only a subset (i.e. imaging sensors, video, MTI…) of sensor data, (e.g. STANAG 4545, 4607, 4609, and 7023). It is difficult to determine intersections (for fusion and cueing) because each of these exchange formats utilizes metadata and sensor models specific to a particular class of sensors. TML will provide a single, data exchange format; thus, eliminating the inherent issues and problems of using multiple data exchange "standards".

If all sensor data can be communicated via this robust sensor data communication language, this enables a common sensor processor to readily process and identify fusible characteristic intersections. TML enables data associations and space-time alignments of similar and disparate sensor data, while being assured that the data necessary for sensor fusion will be there and in understandable and consistent terms. Adding new sensors or modes of sensing to a fusion processor does not require modification or development of new interfaces, adapters, or model translators to the processor.

It may be necessary to fuse sensor data, and/or information products from different systems. Many sensor systems provide their own processing of the raw sensor data and provide a product generally of reduced bandwidth or quantity of data tailored for a particular user. For example, a radar signal may be processed to identify and locate a particular type of target; instead of sending the user all of the raw radar data, only the coordinates of the target are exchanged. In this process, data that is not relevant to the particular user is discarded. This is good for one user but maybe bad for another. The data which was discarded might have been very useful to another user. This is the reason that a post-before-process requirement exists, to enable greater utility from existing sensors systems. TML has the ability to characterize and exchange sensor data at both raw sensor data and product levels.

TML's robustness is gained through its ability to handle multiple sensors and treating time sensitive metadata as sensor data. TML characterizes the exchange of a system of transducers. Many times data from a single sensor is accompanied by other data such as sensor position, attitude, gain settings, sample integration time, etc. TML is able to describe all of this "other data" as sensor data. So instead of having a single sensor with other data (i.e. metadata), TML is exchanging data from many sensors all correlated in time with a time stamp from a common clock. Figure 1 shows how data from multiple transducers combine to form a TML stream for archive or exchange over a network. The actual data from the transducers is pure transducer data, no static data will be exchanged within the data element of the TML stream. Transducers are allowed to be captured or updated at their own characteristic rate, each sampling from a transducer is time tagged with the state of a common clock. This enables the state of each sensor within a system to be determined at any instant. This is extremely important when trying to do direct target positioning from imagery where we need to know the best state of sensor such as the GPS and IMU when a particular pixel was acquired. The adapters will contain the characterization for the particular transducer, or the transducer may contain the characterization itself. This data is static and does not change from system to system. When a new sensor is plugged into a different system the transducer characterization is carried along with the transducer and becomes part of the characterization of the new system. The systems integrator will need to re-establish the links associating that transducer with the other sensors in the systems. This figure may be misleading in some situations. In situations where communications bandwidth is a premium and sensor bandwidths are large it may be necessary to process or pre-processed the data at the source and send only the processed or pre-processed data. In these situations TML will be used to "post" the data prior to processing if archive space is available. Ideally a standard TML adaptor will be available as a front end to the processor or pre-processor to facilitate a common processor acquisition sensor processing.

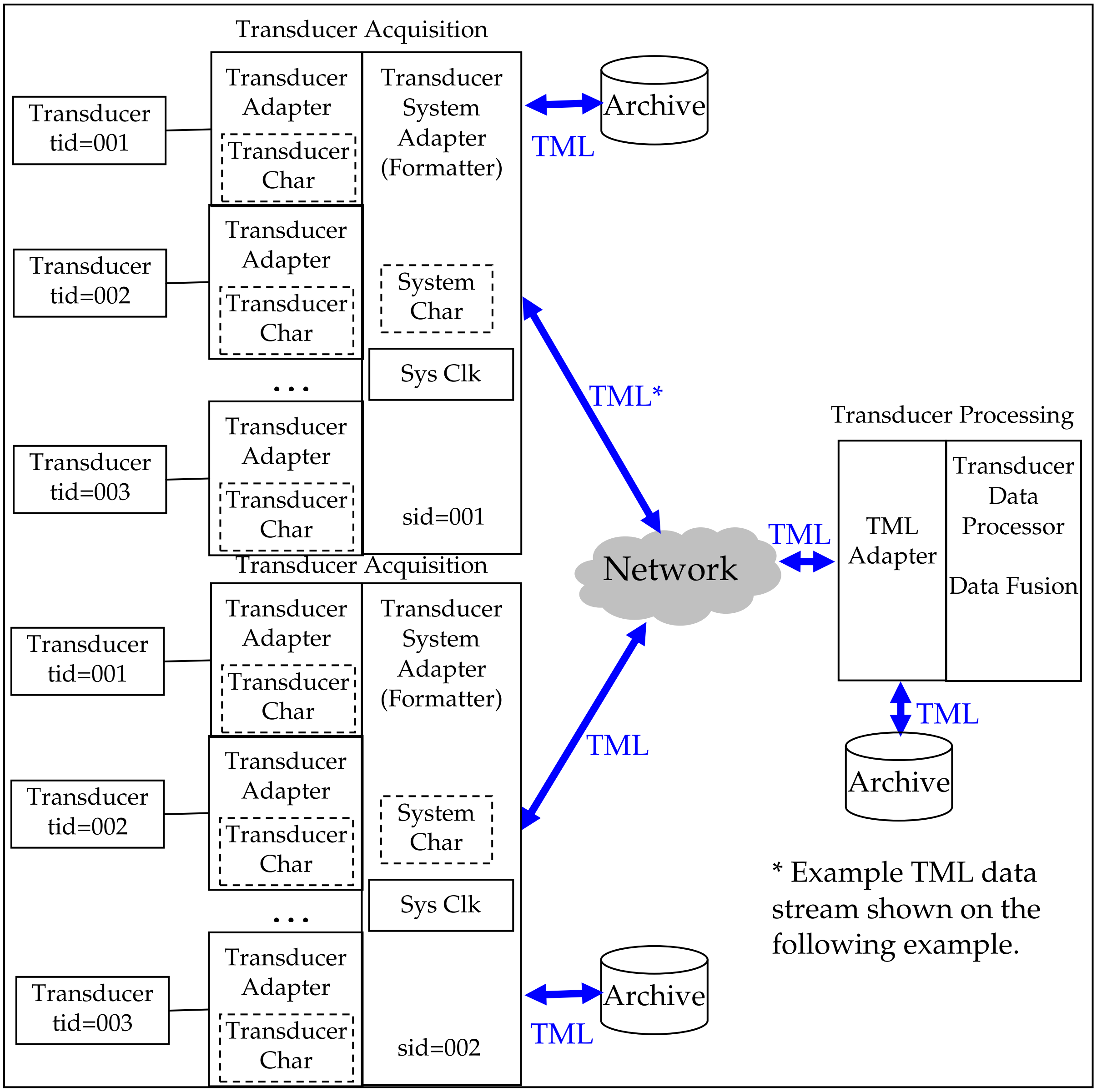

Figure 1 - Generic Transducer System Architecture

A user should be able to search and discover live and archival sensor data, and also reference data sources in one transparent space-time query to find available data in a particular location and time. Figure 2 illustrates how TML would be utilized in a publish-subscribe architecture where the user (subscriber) only pulls relevant information. TML will support the automatic population of search metadata to facilitate the discovery of needed data sets as well as providing information for any level of use (exchange –to- process) of the discovered data.

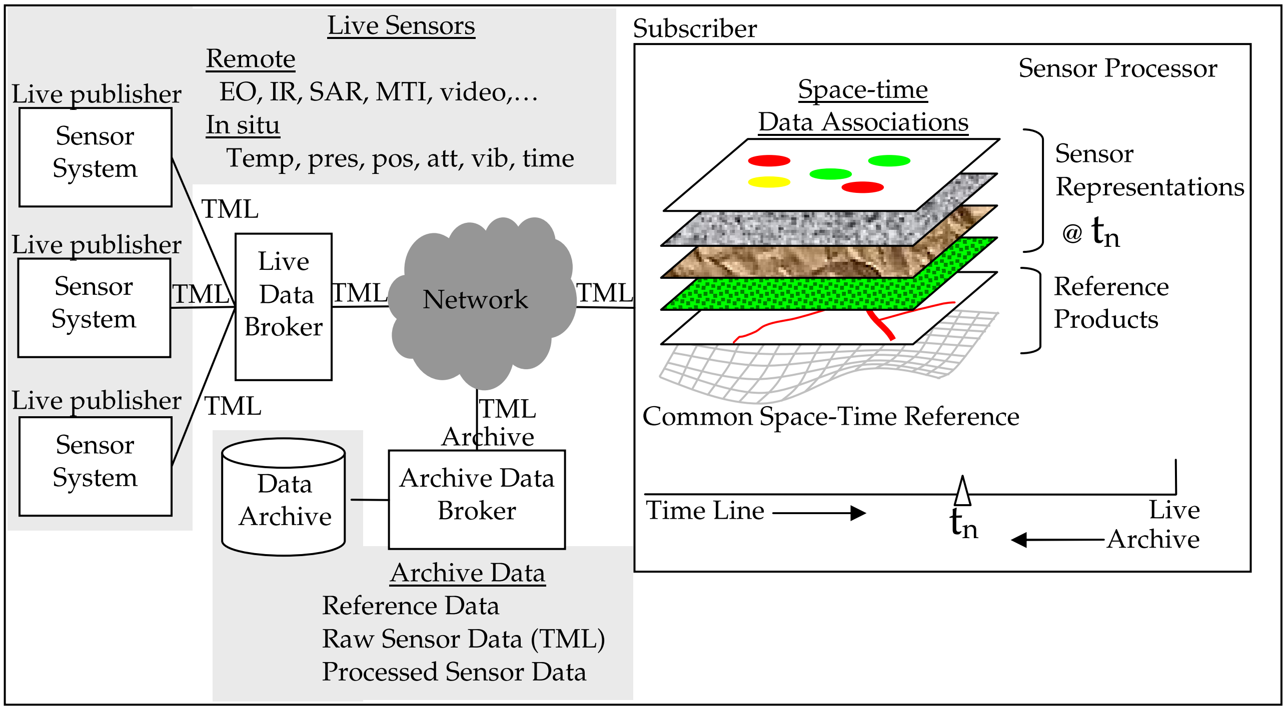

Figure 2 - Interoperability and Fusion of Sensor Data

The following list describes some of the design criteria used in the design of TML. These criteria describe the fundamental concepts/requirements of TML.

- Promote interoperability and fusion of all types of sensor data
- Automatic association between data in space and time from sensors on different platforms.
- Post data before processing
  - Capable of capturing and describing data at any point in a sensor processing chain
- One data exchange protocol for all transducers
  - One transport structure for all transducers
  - One model for all transducers
  - One model for describing special signal processing
  - Adaptable topology to describe transducer systems
- Transducer data processing should be related to physical attributes when possible (e.g. motion compensation)

- Designed to capture data right the first time to the best fidelity that sensors are capable of delivering
- Facilitate common sensor processing, TML must be self-contained. A TML enabled processor should be able to process data from any sensor captured using TML without any other sources of information
- TML exchanges sensor data between sensor formatter and processor and describes to a processor the structure of the data (content, format), the data, the model of the sensor (spatial & temporal characteristics), the relationships of the various sensors in a system, and any processing applied to a sensor signal.
- TML does not describe how to generate a product from sensor data
- TML is application independent, it makes no assumption about how data will be used
- TML is sensor based (streaming) – not display based (multiple discrete files)
- Transducers sample at their own characteristic rate, different sensors within a system will sample at different rates. The exchange should reflect that rate and not some other rate, such that the state of each transducer within a system can be interpolated at any instant.
- TML maintains the relative & absolute time sequencing of data from various sensors within a system
- With TML all data sources & sinks are treated as transducers.
    - Time sensitive metadata comes from a sensor
    - Receiver (sensor) captures time sensitive data
    - Transmitter data captures time sensitive illumination
- Facilitate Plug-n-Play transducers
- Minimize requires processing at the source. The burden of interoperability is on the processor
- When new sensors are introduced, no modifications will be required to a TML enabled processor
- Facilitate the merging of operational support data
- Facilitate the rapid parsing and segmentation of sensor data
- Facilitate real time, minimum latency, data exchange
- Facilitate sensor data discovery
- Facilitate automatic entry of metadata into data products
- Facilitate "smart" pull of information
- Minimize transport data overhead
- TML facilitates network, client/server scenarios
- Every measurement has an uncertainty, the uncertainties need to be characterized
- Transducers may vary in position and attitude. In such cases their position and attitude are relative to either another transducer or an absolute standard spatial datum.
- A "transducer model" maps transducer data to absolute time and space coordinates.
- Describe locus of points which represent the ambiguous solution to the sampling space of each sensor sample
- Don't exchange data which is not supportable (e.g. 3D coordinates from a 2D sensor)
- Facilitate self validation
- Scalability of any level of sensor complexity

Capturing sensor data in a universal language is one thing. Being able to locate particular data of interest is another, especially for sensors which generate streaming or continue outputs. As more and more sensor data accumulates in sensor archives we will need to be able to locate desired data sets. Once data is located and retrieved then we must do something with it. What data is needed to describe a message to or from a transducer? Figure 3 represents a typical message that we may get from a transducer. Unless we know some other information we are not able to use the data. TML will describe the data needed to use this data without other external sources. How much information we need is dependent on what we want to do with the data. If we are only interested in exchanging the data and doing a simple display of the data we will only be interested in the data structure and content. If we are interested in understanding what the sensor is measuring then we will need to understand the transducer or sensor characteristics. If we are interested in registering the data with other data then we will need information on the spatial and temporal characteristics (geometric model) of the data as well as the interactions of the complementary sensors (e.g. sensors measuring exterior orientation) within the system. If we are interested in processing preprocessed sensor data then we will also need to understand what processes the acquired data has gone through. If the data sensor data is delivered in TML the user will have at his disposal all of the necessary information required to do any task desired.

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Figure 3 - Sensor Data

When it is necessary to understand sensor data there is a set of fundamental data (metadata) which is required. TML organizes this data into a common set of metadata required for any sensor simple or complex.

TML will enable the horizontal fusion of heterogeneous sensors, promote data interoperability, and present the war fighter with an integrated seamless picture of the battle space info sphere. With instant and accurate depiction of force deployment both friend and enemy, the war fighter will be able to use live and archival sensor data to provide a historical and real-time perspective of the battlefield. TML is a language for communicating live and or archival streaming signal transducer data between transducer and processor. It was designed to facilitate interoperability of sensors and sensor processors, fusion of heterogeneous sensor data, and the accurate and precise capture of sensor data. Based on XML technology, TML is a sensor data exchange language that allows for the fusion of data at levels not presently achievable (i.e. upstream data). It defines a means to capture and describe streaming raw transducer data and metadata for the purpose of exchanging and processing raw data from disparate sensors through a common processor. TML allows for the capture of special physical sensor metadata that significantly improves the accuracy and effectiveness of intelligence data analysis. Other applications that benefit from the use of TML include:

- Automatic discovery search of metadata entry
- Posting raw sensor data:
    - Facilitates automatic combat ID
    - Better fire control
    - Flight trajectory reconstruction
    - Multi-INT fusion enabler
    - Easier Situational Awareness processing
    - Flexible MASINT processing
- Capture the quality of the data (Sensor error characteristics, e.g. Standard deviations, covariance, etc.)
- Plug-n-play capability
- Facilitate common sensor processing
- Adaptability to new sensors, services, transports, and operational scenarios
- Scalability of any level of sensor complexity
- Automatic association between data from sensors on different platforms.