An overview of the Impactorium tools 2008

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***Abstract*—Decision-makers and analysts need tools that help them make sense of the current situation. Information fusion can provide such tools. In this paper, we briefly describe the current capabilities of the Impactorium set of tools. Impactorium is a collection of software tools used to demonstrate information fusion capability, mainly for Operations Other Than War (OOTW). The software started as a tool for impact assessment, but is undergoing an evolution towards being a framework for both situation and impact assessment.**

I. Introduction

Impactorium is a collection of software tools used to demonstrate information fusion capability, mainly for Operations Other Than War (OOTW). The tool-set has its origins in the "Impact Matrix" tool for impact assessment, but has evolved into a tool-suite that also includes reporting and model construction tools. Current work is aimed at extending it into a framework for situation and impact assessment, and will also in the future include connections to resource management tools. In this extended abstract, we give a short overview of the current version of the tools. The tool-set contains software to

- Create reports, including labelling of them.
- Manage indicators, namely associate reports to the indicators, activate and deactivate indicators, change the values on them.
- Create threat models that define the relationships between indicators and events.
- Visualize events and the likelihood that they will occur.
- Sort and filter reports, depending on criteria that the user sets, for example, that they should have to do with a given report.

A common feature of the programs is that they are based on web services technology. In addition to the client programs mentioned above, there is also a server which, among other things, keeps lists of reports and indicators. All programs include map handling using either Google Maps or in a FOI-internal map server.

II. Preliminaries

This section defines some of the concepts used in the tools. The concepts are described in the way they are used today. This terminology may change in future versions of the software.

a) Report: an observation report made by a human being or a sensor that contains 7S and other information, such as uncertainty in the form of credibility and reliability. May contain indicators and their values, but is not required to do so.

b) Enhanced report: an association between several reports, which also contains a separate list of indicators and their values. The purpose of the enhanced report is to give values to indicators, and also to show what observations reports were used to determine the values of the indicators.

c) Indicator: a kind of classification of the report or fusion result showing that the "report has to do with" a particular event or state. It is a statistical concept that relates an observed event to interesting future events or states: the opponents plan to do X causes them to take action Y, which we observe and use as an indicator that they are planning X. Indicators are stored separately in the web service. Indicators are associated with one or more reports in the program Indicatorium. A report coming into the system may be associated with indicators directly, but need not to be. Indicators may have a geographical link, that is, an indicator can be valid only in a given area. Indicators also have a temporal dimension: their values change as time passes. At present, this is handled by giving each indicator an expiration date when it is no longer valid. An indicator can be a sign of an ongoing activity, one that has already happened, or one that will happen in the future.

d) Event/state: these are the phenomena that we wish to monitor using Impactorium. They are defined by threat models (currently Bayesian networks) that list the indicators linked to it, and a model for how the probability of the event will be calculated on the basis of the indicator values. A state can be described as a snapshot of a part of reality at a specific point in time. Examples of states are unemployment and aggressive mood.

A list of active indicators and events/states with calculated probabilities together form a situation. Different sets of states and indicators are relevant to different users, and can be used to create situation pictures for them.

e) Bayesian network: A Bayesian network is a directed acyclic graph. A nodes children are the nodes that can be accessed directly from the node. A nodes parents are the nodes that are direct predecessors of the node.

III. Tool descriptions

Impactorium can be used to sort, filter and fuse observation reports. The goal of Impactorium is to give the user an

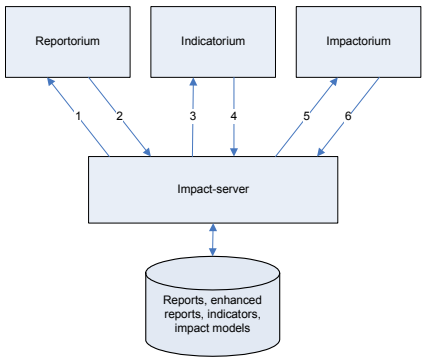

Fig. 1. Overview of programs and data flow in the Impactorium tools. Impact models with associated indicators are created in Impactorium. The list of indicator types used in the models are sent to the Impact server (6) and propagated to the other tools (1, 3). Reports are created in Reportorium and sent to the Impact server (2). Indicatorium reads reports (3) and writes back enhanced reports, containing indicator values and associations between indicators and reports to the server (4). Impactorium reads reports and indicator values from the server (5) and uses them to display information to the user.

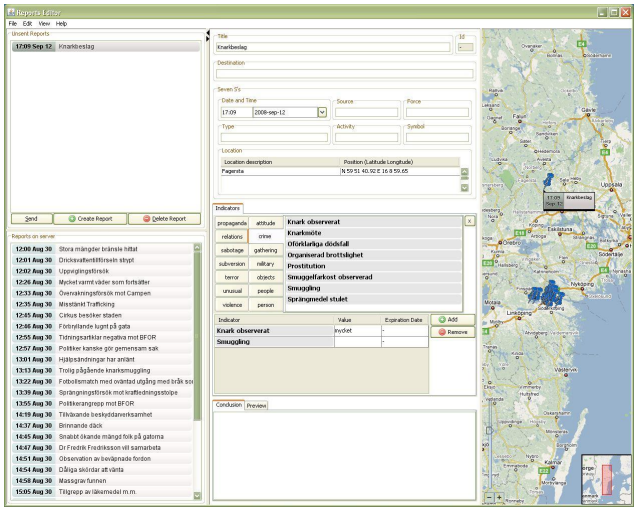

Fig. 2. The GUI of the Reportorium tool. A list of reports is shown on the left, while the middle pane is used to edit new reports. The map to the right allows the user to associate the report with a geographical position.

overview of a situation in order to help them create situation awareness.

Impactorium consists of several components: Reportorium, Indicatorium, and Impactorium, as well as the common Impact-server. Figure 1 shows a schematic view of how the tools are connected.

Observation reports are created in Reportorium. This tool is meant to be used by anybody who reports on observed events or creates intelligence analyses. There are several basic use-cases.

- The tool is used by a sensor operator who uses signal processing methods on the sensor data to understand what the sensors observe and then writes a report about it. Example: A UAV operator who has a separate display where SAR and IR imagery is shown, and then inputs a report on movement of armed vehicles.
- The tool is used by a platoon commander out on patrol to report observations, for example that there are no children playing football on the field where they normally play.
- The tool is used by an intelligence analyst who use open source intelligence to determine that there has been a meeting between a clan leader and a religious leader.

Reports are sent from Reportorium to the server. The reports contain standard metadata (7S information) as well as text written by the user. It is also possible to attach images or video to the report. A report can (but is not required to) also contain information about what indicators it is related to, and possibly even values for the indicators. Figure 2 shows the GUI of the Reportorium tool.

Reports stored on the server are read by the Indicatorium tool. This is a new program to deal with indicators. The user can activate the indicators, change the values of them or disable them. In Indicatorium, the user

- is able to see all observation reports
- can see an ordered list of indicators and can choose to give an indicator a value after reading one or more reports. The reports that caused the user to create an indicator (or change the value of it) are associated with the indicator. Currently, this is done by creating an enhanced report which is stored on the server. In addition to information about the indicators and what reports were used, standard information about who created the association is also stored, as well as an expiry-date when the association is no longer valid.
- can choose to change the value of an indicator after reading new reports. The change will be stored in the indicator history on the server. The user is required to write a short explanation of why the value was changed.
- is required to deal with indicators whose expiry-date has passed. The user must determine if the indicator should be de-activated, have a new value or keep its current value.

Impactorium is the tool that does the filtering of the reports and calculates the probabilities of monitored events. It has been described in earlier publications, but has now been changed to separate indicators from reports. The report list panel of Impactorium now has two tabs, one showing the reports, one showing the indicators, see Figure 3.

Our implementations of Reportorium and Indicatorium both require a human operator. In the future, certain parts of the functionality in the tools can be automated. For example, sensor systems that include advanced enough signal processing components should automatically create a report containing relevant indicators and values for them.

IV. Future work

Current work will extend the Impactorium tools in several directions. In addition to the automation of Reportorium and Indicatorium mentioned above, we will also include tools that help users detect new clusters of reports that may be related

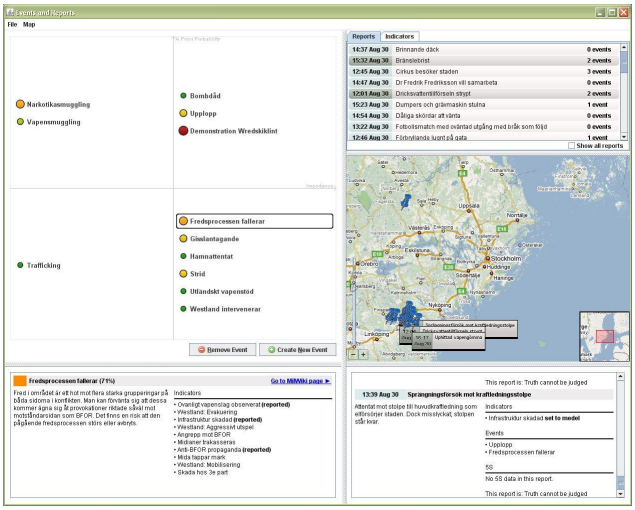

Fig. 3. This picture shows the Impactorium GUI. Monitored events are shown top left, sorted according to their estimated severity and a priori probability. Bottom left, more details on a selected event are shown. On the right, a list of reports, report positions on the map, and details of selected report are shown. It is also possible to select the indicator tab (top right) and see details on the currently active indicators instead of reports.

and should be used to create a new event and the associated list of indicators. This can be seen as a form of knowledge discovery in the stream of observation reports, and we will investigate techniques from the knowledge discovery and data mining research community as well as from traditional fusion for this. We do not believe that it will be possible to automate this process to a large extent. It is very likely that the computer tools will either produce too many or too few new events, and hence it will be necessary that the tool displays information about the candidate new events in an as user-friendly and intuitive way as possible. The reason for why the tool believes the discovered event to be interesting will need to be explained to the user.

It would be interesting to also investigate whether computer-supported collaborative work could be used to improve event detection.

We are also extending considerably the couplings between indicators and events. In future versions of the tools, it will be possible to use an event directly as an indicator of another event. This will in a way make events/states and indicators the same thing.

More work will also go into looking at alternative calculation models that use the values of indicators to estimate probabilities of events/states. Here, there is ample of opportunity for constructing new algorithms that fuse the information in better ways. However, this activity also needs to proceed with some caution, as the new fusion algorithms need to be verified and also possible to understand by the user. One of the major features of the Impactorium tool is the relative simplicity of the computation model used: it is possible to construct threat models that are useful and understandable by the users, and a process can be defined for updating these models in the field. More complicated fusion algorithms would, in all likelihood, require more complicated models. While such models are possible to construct for low-level fusion systems (looking at, for instance, the behavior of fighter-aircraft and making inferences about their intents), it is considerably more complex to do so for high-level fusion. Since we will never be able to construct a perfect model of, e.g., why a riot happens, we will have to settle with one that is good enough to capture the more important features of the process.

Another possible future direction is to replace the indicator types with related searches (both semantic and free text) that will find reports and information from knowledge bases that match conditions that relate to an event or state.

Connections will also be made to the ongoing work on semantic repositories conducted by FOI and the Swedish Armed Forces Joint Concept and Development Center. One possible connection is to evolve the concept of indicators from a static tag into a semantic query that is run in real-time against the semantic database.

A common problem with all these extensions is that we need to define a process for how the intelligence analysts should work with the tools using the new definitions for indicators and events. This process will include not only using the tools to get situation awareness, but also for how to construct the models used in the system.

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