Key performance indicator based calculations as a decision support for the tactical level

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ABSTRACT

For the planning of relief operations the duration and the necessary resources are key factors for a successful completion. Those factors, however, are difficult to estimate due to the large number of influencing factors in a complex crisis situation. This paper presents a software module that supports the planning by calculating the duration and the required resources for relief measures based on key performance indicators (KPI). It is part of a project called SECURITY2People aiming to develop the basics for an integrated disaster management system. The module consists of an easy to use tool to calculate the timing of a relief measure when applied to a given disaster site. In addition it contains a detailed view to display and edit the model of the selected measure which is depicted as a Gantt chart and forms the basis of the calculation. Finally, the paper describes how this module can benefit from interoperability with other modules of this project and existing systems and services.

Keywords

Key performance indicators, tactical level, interoperability, SOA, REST, TSO

INTRODUCTION

Crisis management in a federal, highly industrialized country is carried out by a considerable number of government agencies and relief organisations on several hierarchical levels. Thus, the efficiency of the crisis management strongly depends on the communication between the agencies involved and the information they base their decisions on. That is why the project SECURITY2People was initiated as part of the German Security Research initiative with the goal to provide the basic principles for an integrated information system for all groups involved in crisis management. It's main objectives are:

- Role dependent display and supply of information
- Decision support techniques for all hierarchical levels
- Applicability in training, exercises, planning and operation
- Interoperability with existing software solutions
- Improvement in the exchange of information and the general collaboration between agencies

The project is conducted by a consortium of industrial companies and research institutes and supported by a group of associated partners. Those are executives of several governmental institutions as well as operators of critical infrastructures which contribute to the project in a consultative manner.

One of the decision support modules in the SECURITY2People system is developed by the Institute for Technology and Management in Construction (TMB) at Karlsruhe Institute for Technology (KIT). Its intended field of application is the tactical decision level where it is to be used to estimate the duration of relief measures before they are actually applied. These calculations are based on Key Performance Indicators (KPI) that specify the duration of elementary work steps depending on the given circumstances. This module will be referred to as the KPI-module in this document.

One crucial aspect in the design of the module is its interoperability with other components of SECURITY2People. The goal is to increase the ease of use and the user's efficiency by enabling the KPI-module to share a database with other modules and to automatically request data from other sources of information in- and outside of the SECURITY2People system. Thereby the KPI-module is capable of including real time data about the current disaster situation (e. g. geographical position and status of relief units) in its

calculations.

Despite its focus on tactical and operational demands the functionality of the KPI-module can also aid the strategic level. An executive on that level might be interested in knowing how long it takes to evacuate an endangered district. As (s)he would normally not know about the number of available resources for such an operation (s)he would usually call a person in charge of a tactical department. However, SECURITY2People provides a decision support tool for the strategic level which is capable of requesting information from the KPI-module on the tactical level. The "tactical user" would notice the request which contains all parameters required to answer it and could use the KPI-module to calculate the result and automatically send it back to the strategic module. This saves both sides the time of manually entering data and communicating complex details via phone or email. It was also considered that the users at the strategic level could access the KPI-module directly. This idea was discarded as the results of a KPI calculation may not include all facts needed for an appropriate evaluation of the situation. That is why the calculated result can be commented by the tactical decision maker before sending it to the strategic level.

THE BASIC IDEA: KEY PERFORMANCE INDICATORS TO ESTIMATE THE DURATION OF PROCESSES

Calculations based on key performance indicators are a well-known method to calculate the duration of work processes during the planning of construction operations. A construction manager might for example want to know how long it takes to bring up a wall of a particular size. Assuming there is a KPI giving the average pace of work of a brick layer in m^2/h one can calculate that time by dividing the designated size of the wall by that figure. If for some reason the job has to be done in a shorter time it is of course possible to increase the number of brick layers to speed up the process. However, there obviously exists a maximum number of brick layers depending on the size of the wall to ensure that they will not interfere with each other.

(Chan, A. P.C. and Chan, A. P.L., 2004) shows how KPIs can be used to measure the success of a construction project. This idea is applied to humanitarian logistics in (Davidson, 2006). Similarly, the goal of the KPI-module is to transfer the principle described above to the field of disaster management in order to provide decision makers with a valuable tool to forecast the consequences of their decisions concerning resource allocation. An example for the implementation of this approach based on empirical performance indicators is shown in (Rickers, 1998) with the calculation of the duration of cleanup efforts carried out by typical construction machines such as dozers, trucks and graders after an earthquake. However, in contrast to (Chan, 2004) and (Davidson, 2006), the KPI figures will be used to extrapolate the outcome of a decision before it is made rather than rating the operation retrospectively. In principal any kind of relief measure that consists of a foreseeable sequence of actions and can be described as a structured process could be considered with that method. Obviously this implies the necessity of measuring these actions in field operations or trainings to collect the required data.

The KPI-module in the SECURITY2People system is a software implementation of this idea. It was designed as an easy to use tool to get a quick estimation of the duration of a selected relief measure if applied to a given damage site using a specified amount of resources.

IMPLEMENTATION: KPI-MODULE IN SECURITY2PEOPLE

Figure 1 shows the KPI-module in its current state of development. The two selection lists on top allow the user to choose one of the current disaster sites and an appropriate measure. The module queries the list of current disaster sites from a shared database. A different module containing a situation map might be used to enter additional positions and information about relevant incidents and store it in that database. In order to suggest adequate measures, each incident must be assigned to at least one damage category. For example any incident that involves a fire (e.g. a burning building, vehicle or plane) would be assigned to the category "fire". Based on this approach and loaded with a large set of pre-defined actions/measures, the system is able to suggest reasonable fire fighting measures.

The selection of a measure causes the two tables underneath to refresh and to show both a list of resources commonly utilized for this measure and a list of additionally available resources. By editing those tables the user can select the relief forces to be included in the calculation. For better usability future versions will provide resource assignment via drag & drop.

The calculation is executed by hitting "Calculate duration of measure". It automatically takes into account current data on the given disaster situation such as the geographic position of the damage site and the relief forces and thereby again benefit from the interoperability of the KPI-module. The resulting duration is displayed in the "results" area on the right hand side. The option "Max. duration of measure" will be used for an upcoming

feature that calculates the amount of required resources if a measure has to be carried out in a given time. The compliance of the resource calculations - using only those resources available - with that given time limit will also be shown in "results". This allows a decision maker to rule out options that cannot be completed in time. For example in case of an emission of toxic substances an evacuation of the affected area might be considered. If however, the KPI based calculation points out that the evacuation cannot be completed before the toxic cloud reaches the endangered area, one might refrain from that option and consider sheltering instead and thus preventing people from being exposed to the substance.

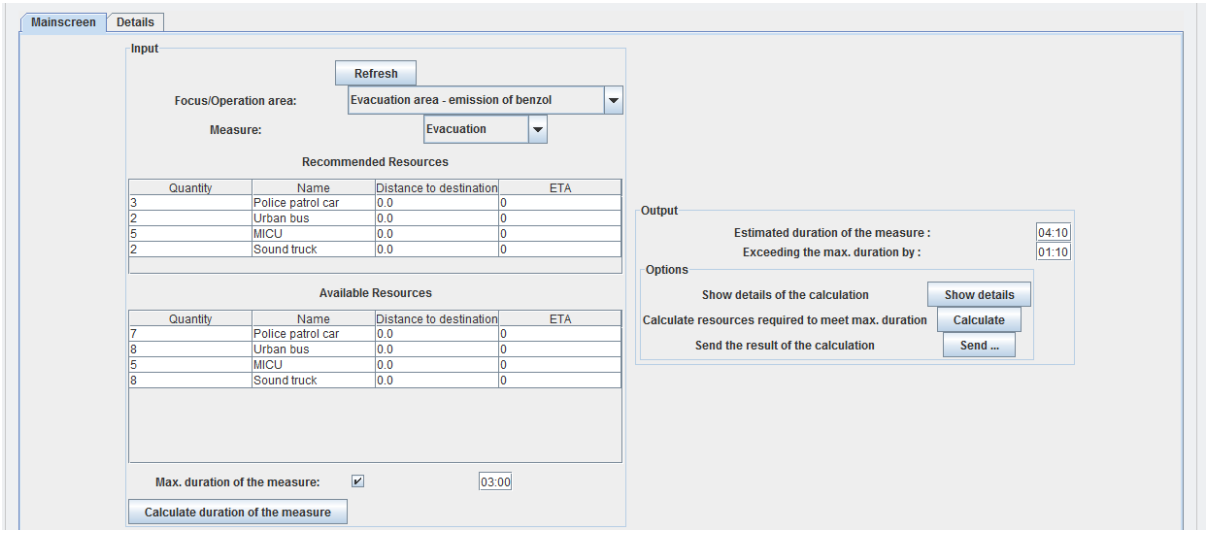

Figure 1. The main screen of the KPI-module

Evidently the KPI-module might assist in decisions that are literally about life and death. Workshops with the associated partners made it very clear that a decision maker would hardly base such decisions on a plain number printed out by a software system without further information as to how the number was calculated. This was taken into account by the "details" button that opens another screen shown in figure 2. Here the user can see the currently selected relief measure depicted as a Gantt chart. The measure is broken down into its single work steps to show their durations and the dependencies between them (e. g. in which order the steps have to be carried out). By double-clicking any of the bars a detailed view opens up, showing how the duration of that work step was calculated. This view allows the user to edit its parameters and to adjust them to the current situation if necessary.

Apart from the usage in actual disaster situations the tool also needs to offer a way to feed the system with knowledge. Therefore the goal is to design the Gantt chart view mentioned above in a way that it can also be used to create new models of measures. Given the fact that these models have to be developed by disaster management experts whose time is scarce, the idea is to provide a modelling tool that allows to start off with simple models that can gradually be refined to more complex models. To accomplish that, the duration of each work step which is represented by a bar in the chart will be calculated by an instance of an elementary KPI model. Such a model has a set of input parameters, and a set of output parameters (usually the duration of the work step or the resources required for it) and a calculation method to derive the output from the input. The KPI model will be build in a generic way so that the input parameters as well as the calculation methods can be provided by various means. For example an input value can be manually inserted by the user or it can be provided by a web service of another module. Furthermore one can combine multiple KPI model instances so that the output value of one instance can be the input of another one. The calculation method in turn might receive a formula from the KPI database but it can also invoke external services to obtain (partial) results for a calculation.

The following example demonstrates how a simple model can gain complexity and accuracy by combining several KPI model instances. The evacuation of a district can be illustrated as a single work step comprising solely the transport of the residents out of the affected area to a safe place. In the simple model the only influencing factors of that work step are the number of people to be evacuated and the number of vehicles available to transport these people, assuming that every vehicle can carry the same number of people. Provided the duration of a single tour from the endangered area to the shelter is another given constant, the duration of the evacuation could be calculated as follows:

$$Duration = \left(\frac{NumberOfPeople}{NumberOfVehicles * SeatsPerVehicle} \right) * DurationOfSingleTour$$

Suppose this simple formula would be modelled by one KPI model instance. Its input parameters (*NumberOfPeople*, *NumberOfVehicles*, *SeatsPerVehicle* and *DurationOfSingleTour*) could all be entered manually by the user. The calculation method would simply implement the formula above to calculate the output parameter (Duration). In order to refine this model one could now create a new KPI model instance which calculates the *DurationOfSingleTour* by requesting the current position of the vehicles and the location of the evacuation area via a web service interface from different modules of SECURITY2People. The calculation method of this instance could then comprise the invocation of a route planning service like Google Maps to calculate an estimated time for a car journey between these two locations. The result of that would be the output parameter of that instance which could be used as input (*DurationOfSingleTour*) for the first KPI model instance. In a similar way other manual input parameters might be replaced by new KPI model instances to achieve a model that is more accurate, requires less manual input and still considers more up to date input values by automatically invoking the appropriate sources of information.

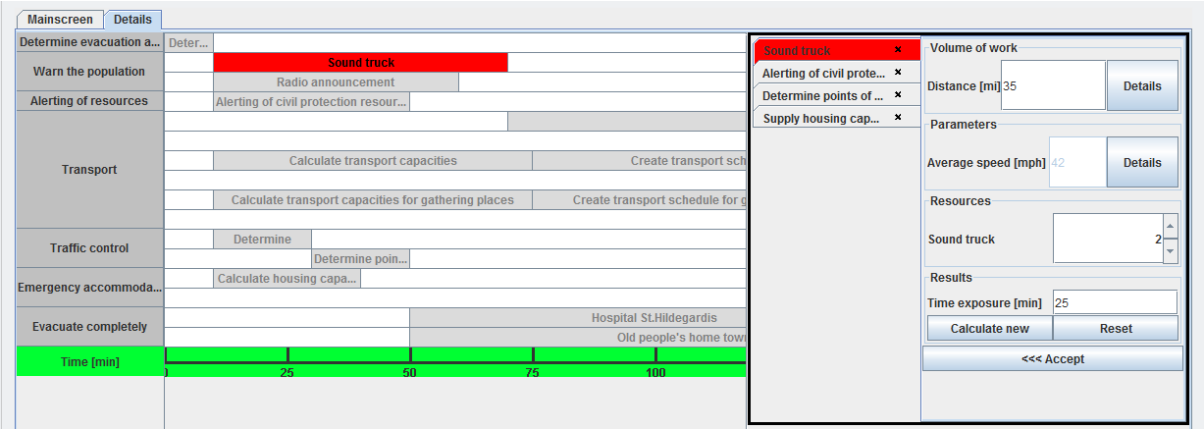

Figure 2. The details view of the KPI-module

INTEROPERABILITY: HOW THE KPI-MODULE IS INTERLINKED WITH OTHER MODULES

The consortium of SECURITY2People decided to implement the system demonstrator as a web application and opted for Liferay Portal (www.liferay.com) as a platform. Thus, the KPI-module is implemented as a Portlet (JSR-268, 2008) which - in its current version - contains a Java applet. This applet is connected to a PostgreSQL database which contains the KPI data. That database is also used by the decision support module for the strategic level mentioned above. This module is presented in another paper at this conference. The shared part of the database contains templates for generic events and measures. Each template comprises fields to describe certain attributes of the event (e.g. location, number of injured, type of event (fire, flood, earthquake, ...)) or measure (e.g. required resources, material and personnel) in human-readable text but also parameters that can be used by both modules in their calculations. When a user enters a new event into the system (s)he needs to fill out a form that involves selecting one of the event templates and then providing details of the specific event and thus creating an instance of the template. Given that instance the KPI-module ideally has all information necessary to calculate the duration of a measure or the resources needed for that measure. Sharing these templates with the strategic module is a step towards semantic interoperability as it encourages people on both levels to use the same definitions for measures and events.

As mentioned above, the KPI-module is capable of exchanging messages with a corresponding decision support module for the strategic level. To ask the tactical level for a KPI-based calculation, the strategic module has to send a request containing the IDs of both an event and a measure stored in the database along with an optional maximum time for the measure. These details serve as input parameters for a KPI calculation. Based thereon, the user can then execute the calculation and send back the (optionally commented) result to the strategic level.

One major goal of the KPI-module is to include data from all kinds of sources (e.g. weather forecast, traffic reports) and provide data to external programmes like management information systems. Therefore the architecture of SECURITY2People is service oriented and features both SOAP web service interfaces (Gudgin, M. et al., 2007) and RESTful (Fielding, 2000) interfaces depending on the requirements. For data exchange between components an XML based container format is under development which will among others utilise the

tactical situation object (TSO) specified by the Oasis project (Oasis Project, 2006) for situation reports.

CONCLUSION

When presenting this demonstrator of the KPI-module to the associated partners in October 2010 the feedback was consistently positive. Apparently there is a high demand for these calculations as nowadays many decision makers seem to estimate the duration of measures relying only on their experience. They admitted that the current procedure should be improved by structuring their expert knowledge and establishing knowledge databases to be used by computerised systems. On the other hand getting hold of KPI-figures turned out to be challenging because either the required data does not exist in a digital form or the proprietors of the data are not willing to publish it.

Ignoring the data question at the moment, further development steps still have to be carried out. Many of the features of the user interface exist only as a concept and have to be implemented whereas the concept of the database structures needs further refinement. The templates for events and measures are still under construction as well as the representation of resources and their capabilities. One goal is to be able to query the resources database by generalized capabilities rather than explicit resource types. In order to determine an appropriate data format existing standards used in well established systems will be considered and utilized as far as possible. It also became apparent that there is already a number of software systems for many tasks in disaster management. However, many of these existing systems do not interact with each other. That underpins why interoperability is of high importance for SECURITY2People. For the future development of the KPI-module this means that extending its interoperability with other modules of SECURITY2People and external services is of utmost importance.

Regarding the future functionality of the KPI-module itself, the major goals are adding the ability to calculate not only the duration of measures but also the resources required for executing measures in a given time. Moreover, there is the idea to combine this module with a situational aware expert system that enriches the calculated result for a measure by hints and advices concerning its execution (e.g. when an evacuation has been calculated the system might remind the user of the currently wintery temperatures and tell him/her to make sure that the temporary shelters for the evacuated people can be heated properly).

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