A redesign of a road traffic accident reporting system using business process simulation

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Abstract *Business process simulation (BPS) is used to evaluate the effect of the redesign of a police road traffic accident (RTA) reporting system. The new system aims to provide timely statistical analysis of traffic behaviour to government bodies and to enable more effective utilisation of traffic police personnel. The simulation method is demonstrated in the context of assisting process change enabled by the use of information systems in an organisation in which there had been a historically mixed pattern of success in this activity.*

Introduction

A case study is presented of a proposed process change initiative to a police road traffic accident (RTA) reporting system. Two aspects of performance of the RTA system require particular attention. The need to speed process execution is seen as essential to provide a faster and more efficient service to vehicle drivers. In particular there is a need to provide UK government agencies, such as the Department for Transport, with accident statistics within a four-week time period. The second aspect of performance that requires improvement is the need to reduce the relatively high staffing cost associated with the process. The total cost of traffic police staff is relatively high as their on-costs need to include the purchase and maintenance of a police patrol vehicle. There is also a need for extensive administrative support at locations across the area covered by the Police Force. This study outlines the construction of a business process simulation (BPS) to estimate potential cost savings of a computerised RTA system, through the use of allocation of staffing costs to activities.

Business process simulation

In general, business process simulation is seen as a way of analysing dynamic systems that exhibit variability. Profozich (1998) outlines the disadvantages of using a static analysis tool such as a spreadsheet for analysing such systems, which requires the assumption that each process will operate on the average. There are however limitations to the method. One disadvantage is the relatively large amount of time and cost needed to develop a model (Pidd, 1998). Further limitations can be apparent in the interpretation of simulation study results. For instance, Fathee *et al.* (1998) state that as the complexity, randomness and variability within a business process increase the range of the prediction obtained from the simulation model becomes too wide for a decision base.

BPS (Tumay, 1996) has been traditionally used in a manufacturing context, but it is increasingly used in service organisations. Levine and Aurand (1994) describe the use of simulation to analyse an automated workflow system of an administration process, Greasley (2000) describes the use of simulation to analyse the custody of prisoner

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process and Verma *et al.* (2000) describe its use in redesigning check-processing operations. The use of simulation to assess the implementation of information systems (IS) in particular has been described by Giaglis (1999) and Giaglis *et al.* (1999) who outline the need to support IS evaluation by developing techniques for generating estimates of the organisational value of IS. Experimental methods such as simulation are suggested as capable of providing such estimates. Warren and Crosslin (1995) suggest simulation as a method of providing the justification necessary to support business decisions to redesign and make what are often massive investments in IT systems. A distinction should be drawn between studies of change to information system process design and change to the information infrastructure itself, in terms of elements such as the IS network configuration, telecommunications hardware and application software. Changes to these aspects are usually undertaken using network simulation software. Painter *et al.* (1996) argue that the process and infrastructure analysis can be integrated and present a methodology to achieve this.

The road traffic accident case study

The case study investigates the computerisation of an RTA system at a Police Force level. The drivers behind the change are to both reduce the cost of the process and increase process execution speed. These objectives are to be met using digital technology to collect and transmit data to a central database, where in combination with information from a geographical information system (GIS) it can quickly provide internal and external agencies with relevant RTA information. Cost savings are to be made from the reduction in RTA officer hours in returning to base to collate and disseminate information and from the centralisation of administrative services leading to more efficient processes. The current and proposed process designs for actions leading from a road traffic accident will now be discussed.

The current road traffic accident reporting system

The current process at the selected constabulary for the reporting and recording of accidents involves a police officer completing a number of paper-based forms following the report of an incident by the public. These forms are distributed to the traffic administration and data HQ departments for processing. The traffic administration section oversees the submission of witness evidence, either by post or in person and the collation of an abstract containing officer and witness statements for use by interested parties such as insurance companies and court proceedings. The data HQ section oversees mapping of the geographical location of the accident that is used for road transport initiatives such as traffic calming and speed cameras. The main stages of the RTA process are now described.

Following the notification of a road traffic incident to the police by the public, a decision is made to attend the scene of the incident. It may be that for a minor incident the parties involved are instructed to pursue proceedings with their insurance companies and the police have no further involvement. If it is necessary to attend the RTA scene the officer travels to the location of the incident. After an assessment is made of the incident the officer returns to the station to complete and submit the appropriate paperwork. Three forms are used by a Police Officer attending a road traffic accident (RTA). Form "54" is used for injury accidents and is triplicated on yellow, pink and white forms. The yellow and pink forms are forwarded by the officer to the witness pro forma process and the white form is forwarded to the data HQ section for location mapping. A single form "55" is used for non-injury incidents which is filed unless further action is to be taken as a result of a dispute or claim, when it is then passed to the witness pro forma process. In addition, pocket book entries (PBE) are taken when no official record is required but provide data that could be retrieved at a later date and transferred to the appropriate form. Amendment of forms may take place at a later date. Form "54" amendment forms contain yellow, pink and white sections for distribution. Form "54" (yellow and pink) and Form "55" amendments are scrutinised to see if changes require further action such as new witness statements. Form "54" (white) amendments are communicated to data HQ.

A location mapping process collates information and passes it to the local council who provide a location grid reference from sketches and location information provided by the officer who attended the accident scene. The data is collated, sorted and then forms are mapped in batches by entering location codes on new forms. If all the necessary information is not available a memo is sent to the officer for further information and the process is repeated. The information is then sent electronically to the local council who return the required geographical location details.

The witness pro forma process obtains accident witness and driver information and places it on a pro forma sheet. If a witness is identified their details are taken and a pro forma is sent to them. If a fatal accident has occurred then the officer obtains further details in person at a later date. If the pro forma has not been returned after three weeks a reminder letter is sent to the witness. If there is still no response from the witness and the information requested is required for further proceedings, then an officer will obtain the statement in person.

The abstract preparation process collates and checks documents associated with the RTA process to ensure all the data needed has been received. A decision is made at this stage if further action is required after reviewing the evidence collected. If further action is required a number of forms are collated. If, at this stage, no prosecution is to take place, a letter informing the driver of this decision is sent. If a prosecution is to take place the officer will write an abstract, summarising the details of the case. If a court case is scheduled and a "not guilty" plea has been entered then the officer will be required to attend the court proceedings in person. Otherwise this is the end of the involvement of the officer.

The proposed road traffic accident reporting system

In the proposed computerised RTA reporting system the attending officer completes paper-based forms as before but this information is promptly converted to digital form using a document image processing (DIP) system. This is achieved by a combination of image capture and data recognition through a facsimile link. Data recognition systems, such as optical character recognition (OCR) are used to process information that is entered in a structured format, such as options selected using a ticked box format. Image capture is used in the following ways. Documents are stored as images to enable input bureau staff to validate the OCR scanned data. Images that cannot be interpreted by data recognition software, such as hand drawn sketches of the RTA scene are stored for later retrieval. Images of text, such as officer-written notes, can be entered by input bureau staff, saving officer time. Once in digital format the documents can be delivered electronically preventing data duplication and enabling faster distribution. Physical documents are held in a central repository for reference if needed.

Location details are currently based on a written description of the RTA by an officer which leads to inconsistent results. The current location description by the officer is usually acceptable for city incidents where nearby street intersections and other features can be used to pinpoint a location. However on long stretches of road it is often difficult to pinpoint an exact spot. This is important because of the need to accurately pinpoint areas with high accident rates for road safety measures (e.g. road humps) and speed camera placement. Further inaccuracies can also occur when the officer description is converted by the local council using an Ordnance Survey (OS) map grid reference which is only accurate to 200 yards. In this proposal each officer is issued with a portable digital map on which to indicate the RTA location. This information is transmitted by a mobile link to a geographical information system (GIS) (Wiley and Keyser, 1998) which provides accurate location analysis of both injury and non-injury incidents using the geocode system (Radcliffe, 2000). The geocode system is a network of grids covering the UK that allow a location to be assigned within a $10m^2$ area. The GIS system will combine the accident location analysis with data relating to the location of pelican crossings, traffic lights, street parking and anything else that might contribute to accidents or affect schemes being proposed. Along with data on details on road conditions at the time of the accident this information will help determine a prioritised list of road safety improvement measures.

The road traffic accident business process simulation

The implementation of the business process simulation will be described in four steps based on the model of using business process simulation to support process centred change presented by Aguilar *et al.* (1999).

Step 1: build and communicate process map

Data requirements for the simulation model can be grouped into two areas. The first area of data is required in order to construct a process map that describes the logic of the model (i.e. how the process elements are connected) and decision points within the process. Decision points can be modelled by a conditional rule based method or by a probability distribution. A process map of the proposed RTA reporting system is shown in Figure 1. Probability distributions for decision points, such as the proportion of injury and non-injury events are derived from the sample data and take the form of a percentage. The second area of data required for the simulation model is for additional elements such as process durations, resource availability schedules and the timing of RTA occurrences. In this case probability distributions for process durations are derived from the sample data. In general a triangular distribution has been used for process durations that requires minimum, mean and maximum parameter values. Resource availability, in terms of a police officer attending the RTA, is assumed to be infinite as an RTA incident is treated as an "emergency situation" and if the designated officer is unavailable an alternative officer is found. Over a period of six years there had not been an incident when no officer could be found, when required, to attend an RTA scene. In terms of the timing of RTA occurrences a three-month sample of road traffic accident (RTA) incidences was collected for the study. Although seasonal

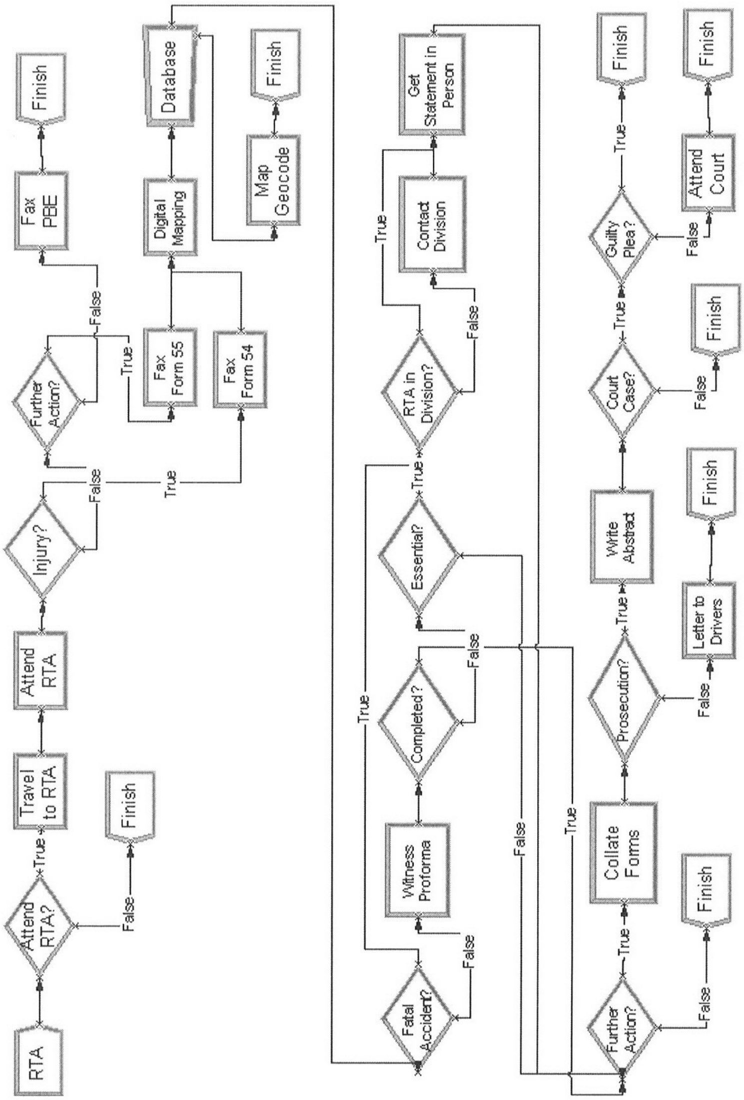

Figure 1.
Process map of the proposed road traffic accident reporting system

variations will occur in RTA patterns, the model is used to compare before and after redesign scenarios and not for forecasting purposes.

Step 2: measure and analyse process performance

The model was built using the ARENA™ discrete-event simulation system (Kelton *et al.*, 2001) that incorporates a template of shapes called blocks that are placed on the computer screen and connected to represent the logic of the model. The user can then mouse click on each block and a pop-up menu allows the entry of parameters such as process durations. The main elements that make up a model are the "Create", "Process" and "Decide" blocks. The "Create" block generates the arrival of people (service applications), physical components (manufacturing applications) or information (information system applications) into the system. These are generically called entities in simulation terminology. It is necessary to define the rate of arrival of entities in the system by defining the time between arrivals (inter-arrival rate). This was achieved using sample data on the timing of the occurrence of RTA incidences. The "Process" block is used to delay an entity for a predetermined time period (to represent the time taken to attend the RTA for example). It is also used to allocate resource time (e.g. traffic officer time) to a process. The "Decide" block is used to define decision points within the process. The entity can leave from two or more outputs from the block. For a two-output decision the routes are labelled true and false. These decision options can be implemented as either a percentage chance for each decision route (e.g. 70 per cent entities follow the true route, 30 per cent false) or by a rule-based decision (e.g. IF x THEN true route, else FALSE route).

Before experimental analysis of the model can begin it is necessary to ensure that the simulation provides a valid representation of the system. This process consists of verification and validation of the simulation model. Verification is analogous to the practice of "debugging" a computer program. In this case the first check was to run the simulation model animation at a slow speed and observe the progress of the entities through the system to check for any logic errors. Then a number of test runs were undertaken and the results of the simulation noted and checked against real system performance and common-sense deductions. A verified model is a model that operates as intended by the modeller. However this does not necessarily mean that it is a satisfactory representation of the real system for the purposes of the study. This is the purpose of validation. In this case the results from the current RTA reporting system model could be compared against historical data of the actual system. A decision is made if model behaviour is close enough to the real system to meet the objectives of the study. Unlike verification, validation is a matter of judgement that involves a trade-off between the accuracy of measurement required and the amount of modelling effort required to achieve this.

Step 3: develop future process design

Because of the probability distributions used for RTA events, process times and decision points, the output measures of the simulation vary each time the simulation is run. Therefore it is necessary to run the simulation multiple times and form a confidence interval within which the average of the measure should lie. In this case the simulation was run ten times for a simulated 28 days for the current and computerised systems. The amount of road traffic officer time in hours was noted for each run for each scenario and a confidence interval calculated at a 95 per cent level. In this case the confidence intervals do not overlap and so there is a significant difference in the results (Robinson, 1994). In other words the difference in the result for the current and computerised systems are not due to random variation alone but due to an actual difference in performance. The results show that the mean officer hours required to undertake all the tasks associated with the RTA process is 2,049 hours under the current system and 1,750 hours under the computerised system. With an on-cost pay rate for road traffic officers estimated at £17.83 per hour this converts to a cost saving of £5,331 per 28 day period or approximately £63,971 per annum.

Step 4: enable and implement future process design
The savings outlined in step 3 are dependent on a number of changes in process design. The need for officer time for transcribing and updating notes will be minimised by the use of optical character recognition (OCR) transcription of officer notes by data centre personnel. A centralised data store will also save officer time by quicker storage and retrieval of information for the pro forma and abstract preparation process. In addition the location mapping exercise will be simplified by the use of portable digital maps from which officers can indicate the RTA location. Process time will be speeded by workflow automation software that will prompt for timely response to requests for information in the witness pro forma and abstract preparation processes. The use of a single point of contact for all data submissions and information requests will also reduce process execution time by eliminating search and delivery delays associated with paper records. The IS system will also have the benefit of improved data accuracy with a single database of all information and location analysis through the use of geocodes.

The simulation study focussed on savings made on the front-line road traffic officer staff but substantial savings can also be made by the centralisation of the traffic administration units. These units are currently located at a divisional level, which is a geographical subdivision of the Police Force area. This is necessary so that paperwork can be processed from officers returning to their local stations. However with the use of digital transmission of RTA information the geographical location of the administrative support can be centralised at a Force level. This can lead to less staff needs due to a centralised automation of processes through workflow and database technologies. The demand on separate divisions would also be aggregated at a corporate level leading to more efficient staff utilisation.

Discussion

The case study has presented the technique of business process simulation used to facilitate business process change enabled by the introduction of an information system. What the simulation was able to do was to both demonstrate how the new process would execute and quantify savings in officer time. Demonstration of the operation of the new design using the animation display reduced uncertainty in how the new system would operate. Observation of performance measures provided by the model helped to secure an acceptance of the need for change by demonstrating the increased performance of the proposed system. In particular information provided by the model of staff cost savings quantified the benefits of change in terms of traffic officer on-costs.

A major issue in the organisation at that time was a lack of confidence in the introduction of IS systems due to the fact that previous IS projects had often been delayed or over-budget. Gulledge and Sommer (2002) outline the importance of aligning information systems with business processes in public sector organisations and although the advantages of the computerisation of the RTA reporting system are evident in increased efficiency, in reality the change requires a number of complex issues to be addressed. These include the integration of the new technology systems with legacy systems (for example the integration of database systems), the management of a reduction in staffing levels and the movement of staff from divisional to a centralised traffic administration unit. While not contributing directly to the implementation of these organisational changes the simulation was able to provide a level of confidence both in the operation of the new process design and quantification of potential benefits in terms of improved efficiency. Both of these factors provided an impetus to initiate the proposed changes.

Further studies could extend this analysis with a study of the information infrastructure required. Thus information on both process and infrastructure costs could be combined to form the basis of an investment appraisal tool for the introduction of information systems. A model of the information infrastructure would also have the advantage of assessing the feasibility of the project in terms of determining a specification for hardware such as communication devices and database systems.

Conclusion

This study has demonstrated the use of BPS to assess business process performance as a result of the implementation of an information system for road traffic accident reporting. The information system offers a number of potential benefits including faster delivery of road traffic accident information to government agencies through the use of digital mapping technology replacing location analysis by a third party. Faster process execution of document flows though workflow technology rather than the movement of paper records is also envisaged. Cost savings in terms of road traffic officer time are gained by eliminating the need to return to the police station to undertake administration duties. Savings are also predicted though a centralised administration facility, enabled through the digitisation of data, rather than paper records kept at a divisional level. The quality of the process is improved by the greater accuracy of road traffic accident location analysis through the use of digital mapping and geocodes. Improved accuracy of RTA information will be gained though the use of a centralised database store replacing paper documentation. Although these potential improvements were recognised there was a lack of confidence in the introduction in information systems due to previous failures. The simulation was able to provide a level of confidence both in the operation of the new process design and quantification of potential benefits in terms of improved efficiency. Both of these factors provided an impetus to initiate the proposed changes.

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