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E-Business Process Negotiation: Formal Requirements for Strategy Support

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1. Introduction

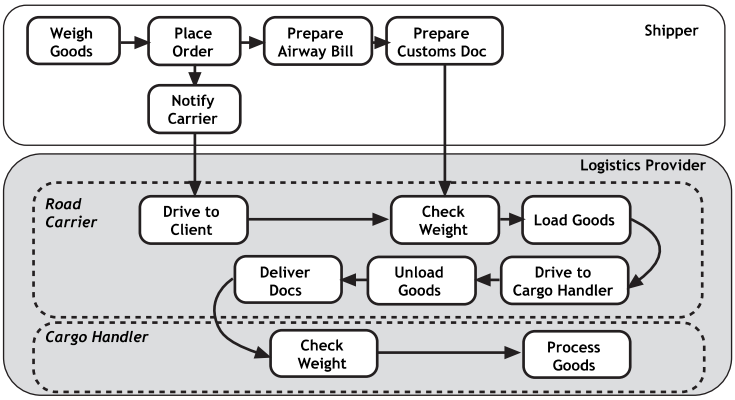
The effectiveness and efficiency of any business-to-business e-commerce venture relies heavily on how the inter-organisational business processes involved (or e-business processes) are designed, implemented and enacted. This has been the impetus behind the substantial IT-related developments in supply chain management [31,50]. A futuristic extension of this theme is the effort to realise dynamically assembled e-business processes in virtual organizations [18,33,37,40]. Web services, some argue, are actually a facet of e-business processes . In all these cases there is the automation of business processes, in whole or in part, by defining the routes it should follow, the roles played by involved entities and the rules triggering the progression of work through it [32]. As such, they fall within the definition of *workflow* and their development should ideally be informed by the theory in this field [30,16,46,55].

Providing effective and efficient support for e-business process negotiation (eBPN) is hence a critical issue in the further development of such ventures. The parties involved are typically autonomous and self-interested. They also typically operate in the commercial world where agreements are formalised as contracts. Negotiation terms could range over the routes, roles and rules of these workflows. This in turn would mean further negotiation of the ownership, control and provision of resources for each of these business process elements. Hence, what is termed negotiation from a commercial point of view can be seen as collaborative design from a workflow modelling perspective. This should therefore be a pertinent issue in workflow theory.

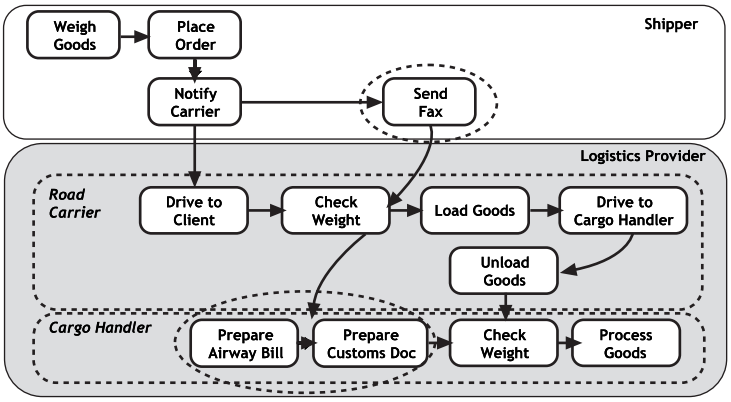
The example of KLM airline parts workflow is displayed in as adapted from . In a commercial context, there will be price and capacity implications for each alternative. If “Shipper” wants to rid itself of the customs documents processing, it has to assess implications of using fax or EDI with respect to business objectives. “Logistics Provider” similarly may want to simplify its own workflow by bidding for alternative ‘A’. Thus, the workflow design is critically impacted by self-interested negotiation.

However, we find that to date eBPN mostly remains an exogenous issue within inter-organisational workflow theory. [10, [52], [5], [28] and are typical examples of this. Most other work in the domain has focused largely on issues that come into play only after the e-business process model is agreed, such as system architecture, analysis and validation (e.g. [56], [41], [23] and [17]). The CrossFlow project [18] has introduced detailed specifications for contracts to enable dynamic workflow assembly in virtual organisations. However, the project has put down negotiations that are “more complex than the current one-step offer-request paradigm” [18,p.289] requiring further work.

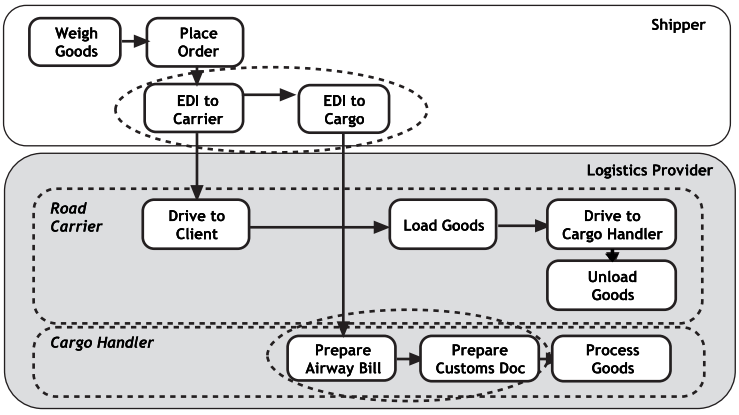
Additionally, CrossFlow delegates any decision-making required while assembling e-business process is to humans without developing any system to support such decisions. This does not mean that discussion of inter-organisational process negotiation is absent from the literature. For example, [9] aim to automate eBPN primarily using quantitative criteria such as a cost or by simply re-ordering conflicting processes. This is based on ideas originally presented in [35]. More recently, [2] proposes an approach using agent-



Alternative "A"



Alternative "B"



Alternative "C"

based technologies. An observation common to such proposed solutions is the absence of a systematic analysis of its requirements. The cited propositions are actually based on certain assumptions about how eBPN is conducted without any reference to concrete

instances from the problem domain. Thus, the extent to which these proposed solutions are sound or can be generalised vis-à-vis eBPN has to be questioned.

Such questions must also extends to other candidate solutions developed independently by *electronic negotiation (e-negotiation)* researchers [4,21,34,49]. As these are developed as non-domain specific solutions, the extent of their applicability to the eBPN domain remains unknown.

As with general e-negotiation taxonomies (e.g , [5], [29] and), [60] such a set of requirements can also guide us regarding the precise combination of systems that is required or where extensions to the state-of-the-art are needed. The above-cited CrossFlow project does provide methodically derived requirements for inter-organisational workflow contracts. However, it does not address other aspects of negotiation support such as "protocol" and "strategy" support.

Therefore, the problem of supporting eBPN remains under-explored. This paper thus describes an essential contribution: a systematically derived and formalised set of requirements for "general" strategy-support in eBPN's (as opposed to "process-specific" strategy support).[1]

To clarify, the definition for strategy is understood as "the specification of the sequence of actions (usually offers and counter offers) the [negotiation party] plans to make during the negotiation" [29,p.35]. "Process-specific" strategy support refers to tools that specifically support the negotiated design of the process being negotiation (rules, routes and roles). However, even contracts on processes contain clauses not directly considered design issues such as "quality-of-service", "level-of-control", etc (see "enactment clauses" in [18]).

Representation of the requirements in regular and unambiguous formal notation is part of the effort to ultimately produce a generic framework that allows efficient and objective evaluation of eBPN problem scenarios vis-à-vis candidate solutions. Even the limited set of requirements presented in this paper, when applied in this manner, have already demonstrated a major shortcoming in some recent and oft-cited e-negotiation systems: the lack of a holistic negotiation approach.

The paper is structured as follows. Section discusses the methodology followed in execution of the requirements analysis. Scope considerations that apply to the methodology are covered in Section . Section then explains the resulting "general" strategy-support requirements along with their formal representation. Section demonstrates the utility of this formal framework for system evaluation. Section , provides a summary evaluation of some state-of-the-art negotiation support systems. Section , briefly touches upon the proposed new eBPN approach, SEPNA[2] and *SEPNA-Sys* (its demonstrative implementation), highlighting their inception as the result of framework-based evaluation. Details regarding formal notation used and complementary formalised concepts are covered in the appendix.

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[1]These and other requirements are expected to be discussed in a forthcoming publication issuing from the more general investigation documented in [43]

[2]Although SEPNA was originally introduced in , the version in represents a richer refinement of the preliminary ideas presented earlier.

2. Methodology

Following a "systematic approach" is understood to imply that a clearly stated and reasoned methodology is followed at the outset. This includes justification of the choice of inputs, the process used and the form chosen for the outputs.

In essence, the methodology followed in our requirements analysis uses three case studies from the e-business process domain as inputs: (i) a logistics case-study [11-13] extended by [42, Ch. 4]; (ii) a motor insurance case-study [7,8] and (iii) a telecoms case-study [24]. The process involves application of taxonomies developed independently in the electronic negotiation (*e-negotiation*) literature [4]. Note that the application of techniques from the more mature[3] The details of the specific steps involved in the methodology are as follows:

a. General requirements recognised in the workflow literature:

Obvious and fundamental deductions have been recorded immediately by analysis of general issues of concern in inter-organisational workflows reported in the literature. These include the issues of autonomy, confidentiality, interoperability and switching workflow partners at run-time (*dynamic switching*) [3,23,44]. While the core of the methodology relies on the taxonomies from the e-negotiation domain, this is a preliminary step. It guards against omission of basic requirements specific to e-business processes that may be ignored by the more generic e-negotiation taxonomies. For example, the need for interoperability and confidentiality requires the negotiation support system to translate between public and private models of processes contained in negotiation proposals.

b. Apply two accepted models for e-negotiation analysis:

The Montreal Taxonomy [51] is then applied to the case studies.[4] Though it is a work-in-progress, it provides a first port-of-call as an amalgamation of previous e-negotiation taxonomies (e.g. [60], [29] and [15]). The logistics case study is the primary input while the other two serve to validate any findings. The schema developed by Lomuscio et al. [29] is also then applied to the case-studies to compensate for aspects not covered by Montreal Taxonomy, such as "agent rationality", "attitudes to commitment", "social behaviour" and "dynamism of the negotiation environment".

3. Analysis of specific logistics case study:

General and specific scenarios relating to the logistics case study have been documented in [42], derived based on requirements noted in [12]. By applying further logical deductions to these scenarios, more requirements are captured that may have escaped preceding steps. Again this is especially with regards to those specific to the workflow domain (see example in Step 1).

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[3] As demonstrated in the literature surveys and . e-negotiation domain within workflow theory is a novel line of enquiry in itself.

[4] It is only the 'endogenous explicit criteria' in the Montreal Taxonomy that are applicable here.

d. Validate against other case studies:

Again, case-study specific observations are only recognised after validation against the other two case studies. Following this process, a number of requirements have been identified and classified using general e-negotiation analysis dimensions of "object", "protocol" and "strategy"[4,22,29]. Requirements pertaining to strategy (as defined in the latter part of Section 1) have been further sub-divided into "general" and "process-specific". In this paper, it is the general strategy requirements that are presented.

3. Scope

The requirements analysis has been guided by certain scoping considerations. Those applicable to the general strategy requirements are noted as follows:

a. A "first round" of requirements analysis:

This is an initial investigation into requirements where it is deemed not necessary to directly consult potential users and system-owners. This is due to a phenomenon most cogently expressed by Brooks [6, p, 20]: "I would … assert that it is really impossible for clients, even those working with software engineers, to specify, completely, precisely, and correctly the exact requirements of a modern software product before having built and tried some versions of the product they are specifying." eBPN systems fit the label of "modern software product" and so this round of analysis is focused on the development of prototypical systems to elicit input from future users.

b. Focus on bargaining-type situations:

Bargaining-type negotiations differ from auction-type ones essentially as they lack a pre-defined set of terms that are negotiable (i.e. the negotiation object) and consequently do not follow a pre-defined set of rules of interaction (i.e. the negotiation protocol) [4,27]. Current e-negotiation research has largely focused on auction-type structured negotiations [14,20,22,34]. Hence, this investigation has focused on instances of eBPN where current auction systems will not suffice.

c. Co-operative agents are assumed:

A major complication in e-negotiation systems development is where a protocol design may be undermined by "cheating" of participating agents [36]. Being a general issue in the design of negotiation protocols, it is deemed beyond the scope of this investigation.

It is asserted at this point that as the methodology and its scope limitations have been clearly articulated, a systematic procedure does underpin the requirements gathering process. It is guided by the use of e-negotiation analysis dimensions to provide more completeness, objectivity and efficiency to the process. The following section now discusses a chosen sub-set of the results. These should be sufficient to later demonstrate the significance of these findings.

4. Requirements for General Strategy-Support (GSS)

The following sub-sections both explain the requirements discovered under this heading and also present their translation to formal notation. This is complemented by the appendix which explains some of the notation used and covers formalisation of other supporting concepts.

4.1 GSS1 – Intermediate Data-set

The Lomuscio et al schema [29] inquires whether the negotiation needs access to data from the "environment". In an eBPN context, this should not only include general data coming from external sources (such as trust ratings, partner history, etc. [9]) but also data held privately by each party regarding their own local workflows.

For example, in the CrossFlow logistics scenario, external data could include past delivery times statistics of the bidding carriers. Additionally, as the logistics provider doesn't expose all its processes due to confidentiality concerns, the strategy-support system requires data on private processes, such as order-handling. Also, an effective system would need access to decision-relevant statistics that are produced only after combining the workflow in a counterpart's negotiation proposal with one's own workflow and performing relevant simulations.

All such data, termed "extra-negotiation" data, needs to be captured. Hence, there is a requirement for an intermediate data-set that collates both extra- and intra- negotiation data, as a combined input object for the strategy-support system. The role of the intermediate data-set is formally specified as follows:[5]

$$\begin{aligned} InterimDataSet = \{ interimData \mid & \\ & interimData \subseteq Evaluations \bullet \exists proc : DecSuppProc \\ & \bullet \exists interToEval : \mathrm{DSPRel}()proc \\ & \bullet interToEval : interimData \rightarrow \mathrm{Dom}(proc) \}\ . \end{aligned} \qquad \textbf{(GSS1.1)}$$

Therefore an intermediate data-set (i*nterimDataSet*) is one for which there exists an operation in a decision-support process that can include it in the domain of the processes, i.e., the set of evaluations from rankings will be derived.

This intermediate data-set should support the evaluations derived from negotiation attributes. This is specified as follows:

[5]Refer to appendix for specification of unexplained formal notation.

$$
\begin{aligned}
&NegMapInSet = \\
&\quad \{\text{negMap} \mid \forall d\ D : \bullet : \text{negMap} \\
&\qquad \times InterimDataSet \times NegMsgPossAttrib \\
&\qquad\quad \times \text{Eval}(d, A)\ \times A \times FuncMapIn \rightarrow InterimDataSet \\
&\qquad\qquad \bullet\ \text{negMap}(interim, m, x, eval, a, f) = interim'\} \\
&\text{where}\quad \text{Dom}(interim') = \text{Dom}(interim) + \{eval'\} - \{eval\}, \\
&\qquad \text{Gr}(eval')\text{Gr}(=eval) - \{(a, eval(a))\} + \{(a\ f, (x\ eval))\} \text{ and} \\
&\qquad x \in m\ .
\end{aligned}
\qquad \textbf{(GSS1.2)}
$$

(GSS1.2) therefore provides for an operation that amends an *eval:*Eval(*d, A*) for a given decision-maker and then requires the intermediate data-set to include it in its set of evaluations. This can later be included in the decision-support process itself, as stated in (GSS1.1). The *eval* is provided with the value arising from *f*(*x,eval*), that belongs to a specific negotiation message.

The important need to capture extra-negotiation data can now be specified as:

$$
\begin{aligned}
&\forall interim : InterimDataSet \bullet \forall negMap : NegMapInSet \\
&\quad \neg((eval \in interim) \Rightarrow (\text{Ran}(eval) \neq \text{Ran}(negMap)))\ .
\end{aligned}
\qquad \textbf{(GSS1.3)}
$$

This basically means that an evaluation can be included in *interim:InterimDataSet*, that is **not** necessarily derived from the attributes of a negotiation message.

Next, the intermediate data-set should be persistent in an interoperable format so that data from other software systems (e.g. simulators, workflow management systems, DBMS's, etc.) may be included in it. Without these requirements, workflow cost calculations by interfacing with an organisation's enterprise system (ERP), such as those foreseen in , are not possible. For such systems to provide the relevant data, they may initially need to interface with the intermediate data-set as an input. Hence, both importing from and exporting to operations must be applicable to the intermediate data-set. Formally, therefore, interoperability would mean that there exists an operation that can map the software system's output into a set of evaluations that form part of an *interim:InterimDataSet* and vice versa. Hence, the requirement for interoperability can be specified as follows:[6]

$$
\begin{aligned}
&\forall interim : InterimDataSet \bullet \forall s : SoftSys \bullet \exists in : \text{SoftSysRel}(s) \\
&\quad \bullet in : s \rightarrow interim\ .
\end{aligned}
\qquad \textbf{(GSS1.4)}
$$

and

$$
\begin{aligned}
&\forall interim : InterimDataSet \bullet \forall s : SoftSys \bullet \exists out : \text{SoftSysRel}(s) \\
&\quad \bullet out : interim \rightarrow s\ .
\end{aligned}
\qquad \textbf{(GSS1.5)}
$$

[6] *SoftSys* and SoftSysRel are formally defined in the appendix.

As simulation of the combined e-business process may often only be derived after proposals from negotiating entities have been received, the intermediate data-set should not only be extensible, but should be changeable over the course of a negotiation session and not pre-defined. Thus the intermediate data-set is to be *"dynamically extensible"*, formally specified as follows:

$$\exists \text{AddInterimData: } InterimDataSet \times Evaluation \text{ a } InterimDataSet$$
$$\bullet \text{AddInterimData}(interim, eval) = interim'$$
$$\Leftrightarrow interim' = interim + \{eval\} \quad \textbf{(GSS1.6)}$$

and

$$\exists \text{RemInterimData: } InterimDataSet \times Evaluation \text{ a } InterimDataSet$$
$$\bullet \text{RemInterimData}(interim', eval) = interim$$
$$\Leftrightarrow interim = interim' \dot{-} \{eval\} \quad \textbf{(GSS1.7)}$$

The lack of restriction on when this is to take place ensures the conditions are to be valid even while the negotiation is taking place.

4.2 GSS2 – Multiple views of single negotiation message

Using the Montreal Taxonomy, it has been identified that the attributes in the offer specification cannot be determined before-hand (bargaining-type negotiation). Also the attributes themselves can be "multi-valued". Similar considerations are found when examining "good characteristics" in Lomuscio et al. framework. Moreover, "what-if" analysis is an integral part of choosing between alternative strategic options.

As a result, multiple intermediate data-sets may correspond to a single negotiation message, as attributes are subject to a range of values and different attribute sets may be represented in a variety of intermediate data-sets. For example, in the logistics case study, the logistics provider may well receive the proposals shown in from two pick-up/delivery (PUD) carriers. If the logistics provider opts for PUD B's proposal p-167, covering only the 5-10kg service categories, it may still wish to provide for the 20kg from an alternative source, e.g. either obtain an alternative bid for just the 20kg category from A or use its in-house resources. Thus at least two intermediate data-sets would be needed in order to evaluate the two alternatives (i.e. in-house vs. outsource) arising from the single proposal p-167.

Table 1. Proposals p-165 & p-167 received from PUD's A and B respectively

Negotiation attribute	PUD A: p-165	PUD B: p-167
Price (for identical service period)	£35,000	£25,000
Next-day delivery QoS guarantee		
• Less than 24 hrs	95%	98.5%
• Between 24 & 48 hrs	5%	1.5%
Service Options (weight classes)	5, 10 & 20 kg	5 & 10kg only

Formally, this first requires the existence of an operation that allows association of an *interim:InterimDataSet* to a *negMsg:NegMsg*. This is specified as follows:

$$\exists \text{AttachInterim} : \mathit{InterimDataSet} \rightarrow \mathit{NegMsg} \ . \qquad \textbf{(GSS2.1)}$$

GSS2 stipulates further that:

$$\forall ij,: \mathit{InterimDataSet}$$
$$\bullet \neg((\text{AttachInterim}(i) = n \wedge \text{AttachInterim}(j) = n) \Rightarrow (i = j)) \ . \qquad \textbf{(GSS2.2)}$$

This means that it is *not* necessarily the case that only one intermediate data-set can be attached to a negotiation message.

4.3 GSS3 – Ability to define custom mapping rules

Often, the data input into the decision-support process is the result of synthesising various intermediate data resources into a single evaluation. For example, in the insurance case study, the calculation of the cost of the overall workflow will require not only pooling together the individual workflow costs of the main insurance company, its customer contact agency, the agency managing the garages, etc. but also the workflow integration costs and costs of discontinuing existing arrangements. Thus various mapping rules may be applied in collating the evaluations to include in the intermediate data-set ready as input for the strategy support system. This is formally specified as follows:[7]

$$\forall \mathit{fFuncMapIn}$$
$$\bullet \exists \text{AddInFunc}: \mathit{NegMapInSet} \times D \times \mathit{FuncMapIn} \rightarrow \mathit{NegMapInSet}$$
$$\bullet \text{AddInFunc}(\mathit{negMap}, d, f) = \mathit{negMap}'$$
$$\bullet \exists (i, m, x, e, a, g) \in \text{Gr}(\mathit{negMap}) \wedge g \neq f \ \wedge \ e \in \text{Eval}(d, A)$$
$$\Rightarrow \text{Gr}(\mathit{negMap}') = \text{Gr}(\mathit{negMap}) + \{(i, m, x, e, a, f)\} \ . \qquad \textbf{(GSS3.1)}$$

$$\forall \mathit{fFuncMapIn}$$
$$\bullet \exists \text{RemInFunc}: \mathit{NegMapInSet} \times D \times \mathit{FuncMapIn} \rightarrow \mathit{NegMapInSet}$$
$$\bullet \text{RemInFunc}(\mathit{negMap}', d, f) = \mathit{negMap}$$
$$\bullet \exists (i, m, x, e, a, f) \in \text{Gr}(\mathit{negMap}') \wedge \ e \in \text{Eval}(d, A)$$
$$\Rightarrow \text{Gr}(\mathit{negMap}) = \text{Gr}(\mathit{negMap}') - \{(i, m, x, e, a, f)\} \ . \qquad \textbf{(GSS3.2)}$$

4.4 GSS4 – Concurrent use of all soft and hard data

The need for three things is implied here. Firstly, both soft (i.e. subjective) and hard (i.e. objective) data need to be modelled within the system. This recognises that a significant source of criteria evaluations in eBPN are human judgements [30]. In fact, it is usually the *raison d'être* for recourse to unstructured bargaining protocols as the object of negotiation itself can not be formally pre-defined. For example, in the

[7] Refer to appendix for specification of *FuncMapIn* and *NegMapInSet*.

insurance case study, the service quality expected of the "24hr quality emergency service"[7, p,4] is likely to be critical in selecting a workflow partner. In the logistics case study, delivering "within 24 hours" may have an additional implicit advertising value. This "soft" aspect of the delivery time may result in "less than 24 hours" offers being disproportionately preferred over offers of "36 hours" or "48 hours". Thus, even quantitative evaluations may be reinterpreted based on subjective considerations. Firstly, therefore, GSS4 stipulates the following:
Given *proc:DecSuppProc* is the decision-support process in question,

$$\forall d : D \bullet \forall EvalSubset \subseteq \text{Eval}(d, A) \bullet \exists ranking : PossRanking \bullet proc(EvalSubset) = ranking \quad \Rightarrow \quad EvalSubset \cap \text{Subj}(d, A) \neq \varnothing \quad \text{(GSS4.1)}$$

Secondly, what is also implied is that *all* the data required to be included for a given decision-maker is captured in a single mapping of alternatives to rankings. Note that this applies where Subj(*d*,*A*) ? . Formally, if *proc:DecSuppProc* is the decision-support process,

$$\forall d : D \bullet proc : \{\text{Eval}(d, A)\} \text{ a } PossRanking \quad . \qquad \textbf{(GSS4.2)}$$

with total function symbol emphasising that *all* evaluations needed by *d* are used in mapping to *PossRanking*.

Thirdly, it is understood that the data should be processed in a manner acceptable to the decision-maker. This is more difficult to specify as the decision-maker will not necessarily be the designer of the decision-support process. However, this stipulation is to qualify the term "use of data" as it could be misused to produce faulty rankings. For example, suppose the decision-maker subjectively ranks all alternatives with respect to "Quality". The decision-support process should not rank an alternative considered "excellent" in this criteria as the lowest overall. The method devised to protect against this, in this specification, is to ensure that the decision-maker has "consented" to the specific operation that takes the evaluation as part of its input. Thus formally, this may be expressed as follows:

Given *proc:DecSuppProc* is the decision-support process in question,

$$\exists R : \text{DSPRel}(proc) \bullet \exists d : D \wedge eval : \text{Eval}(d, A) \bullet \exists y \bullet (eval, y) \in R \Rightarrow d \ Consents \ R \quad . \qquad \textbf{(GSS4.3)}$$

Here *Consents* is true iff *d:D* has consented to the function *R* that forms part of the composite function *proc*. Note that consent is assumed to exist if the decision-maker is the designer of this operation or provides inputs that define the parameters of this operation.

4.5 GSS5 – Dynamically changeable criteria set

Enactment clauses, specified in the CrossFlow contract template [15], define quality of service (QoS), level-of-control (LoC) and flexible activity ordering clauses. As these are contingent upon the the workflow model definition, they will consequently also be subject to change *during the course* of the negotiation. For example, in [11] , where

the business process of the customer needs to be re-designed in order to enable dynamic re-configuration, new process ownership (i.e., LoC) concerns will dynamically arise during the negotiation of this modified workflow.
As a result, as in GSS1.6-7, the criteria used to evaluate alternative e-business process proposals are likely to vary in a dynamic fashion as well. "Flexibility" and "robustness" of the resulting workflow, for example may suddenly become an issue when moving from a traditional workflow design to the new one. Formally, therefore, GSS5 stipulates that given *d:D, eval:Evaluation* and *proc, proc':DecSuppProc*

$$\begin{aligned} &\exists \text{AddEval: } DecSuppProc \times Evaluation \text{ a } DecSuppProc \\ &\quad \bullet \text{AddEval}(proc, eval) = proc' \\ &\text{where} \quad proc' : \text{Pow}(\text{Eval}'(d, A)) \rightarrow PossRanking \text{ and} \\ &\qquad \text{Eval}' \; d, A \; \text{alEv} = \{\}. \; (d, A) + (eval) \end{aligned} \qquad \textbf{(GSS5.1)}$$

This means that GSS5 requires the existence of such an operation that would allow the decision-maker to add an evaluation to the set of evaluations from which the system will derive rankings.
GSS5 would also stipulate the existence of another operation that allows the removal of an existing evaluation:

$$\begin{aligned} &\exists R : \text{DSPRel}(proc) \bullet \exists d : D \wedge eval : \text{Eval}(d, A) \\ &\qquad \bullet \exists y \bullet (eval, y) \in R \Rightarrow d \; Consents \; R \; . \end{aligned} \qquad \textbf{(GSS5.2)}$$

proc', proc and their features are as specified for (GSS5.1).
Then it is also stipulated that evaluation values should be changeable, i.e.

$$\begin{aligned} &\forall d : D \bullet \exists scale : Scale \\ &\quad \exists \text{ChangeEvalVal} : DecSuppProc \times \text{Eval}(d, A) \times scale \rightarrow DecSuppProc \\ &\qquad \bullet \text{ChangeEvalVal}(proc, eval, s) = proc' \\ &\text{whereDom}(proc') = \text{Dom}(proc') + \{eval'\} - (eval) \\ &\qquad \text{Gr}(eval') \; = \text{Gr}(eval) - \{x\} + \{y\} \\ &\text{with} \quad eval \in Evaluation \Rightarrow x = (d, a, eval(a)) \wedge y = (d, a, s) \text{ given } a : A \; . \end{aligned} \qquad \textbf{(GSS5.3)}$$

As in GSS1.6-7, no restriction is specified as to when this is possible. The evaluation set can be dynamically changed even while the original decision-support process is in progress.

4.6 GSS6 – Ability to define criteria relationships

Given the need for human-defined subjective evaluations as inputs (GSS4) the ability to define relationships between criteria and thus define high and low level criteria is observed as a strategy support requirement. This is supported by recommendations in management science literature to use Pareto analysis which follows the 80/20 rule [25,47]. Additionally, hierarchically developing many low-level considerations into a few high-level ones is one means available to overcome the limitations of bounded rationality [45,46,58].

Merging low-level criteria into high-level ones requires mappings or relationships to be defined between the criteria. For example, in the logistics case study, a quality criterion may be formed by the accumulation of scores for "process reliability", "customer satisfaction ratings" and "past performance".

Such relationship arrangement should also map well to hierarchical management structures for decision-making. Lower management may populate scores for operational level criteria while higher management may do the same for high-level or strategic criteria.

Thus GSS6 stipulates that:

$$\begin{aligned}\forall d : D \bullet \exists \text{MakeSub} : & \; DecSuppProc \times \text{Eval}(d, A) \\ & \times \text{Eval}(d, A) \times PossEvalOps \\ & \times PossEvalCombs \rightarrow DecSuppProc \\ \bullet \; & \text{MakeSub}(proc, \text{sup}\, sub, evalOp, evalComb) = proc' \\ \bullet \; & \text{Dom}(proc') \; \text{Dom} = \; (proc) + \{sup\} \\ \bullet \; & sup' = evalComb(\text{sup}, evalOp(sub)) \quad . \end{aligned} \qquad \textbf{(GSS6.1)}$$

That is, there exists an operation that allows one evaluation (*sup'*) to be added to the domain of the decision-support process such that it is the combination (*evalComb*) of an operation on another criteria and any previous representation of the evaluation that existed in Dom(*proc*).

4.7 GSS7 – Soft-coating

Another more specific requirement that relates to GSS4, is that the system should allow over-riding of objective evaluations in order to convert them to subjective ones. This is what is being termed as "soft-coating".

The delivery example given for GSS4 that illustrates this need is where the time preference may not be linearly related to its actual quantity e.g. 24hrs delivery may attract a disproportionately larger priority than 36 or 48 hrs.

Formally, we want to test for the existence of an operation in the system that would allow such "soft-coating" of objective data, as follows:

GSS7 stipulates that **for all** *d:D, obj:*Obj(*d, A*), *subj* and *proc, proc':DecSuppProc*

$$\begin{aligned}& \exists scale : Scale \bullet \text{MakeSoft} : DecSuppProc \times \text{Obj}(d, A) \text{ a } \; DecSuppProc \\ & \quad \bullet \; \text{MakeSoft}(proc, obj) = proc' \\ & \text{where } \; proc' : \text{Pow}(\text{Eval}'(d, A)) \rightarrow PossRanking \\ & \qquad \text{Eval}'(d, A) \; \text{Eval} = (d, A) \\ & \; but \quad \text{beforeEval}(d, A) \; \text{Obj} = \text{Subj}(d, A) + (d, A) \\ & \text{whilenowEval}(d, A) \quad \text{Obj}' = (d, A) \text{Subj}' + (d, A) \\ & \qquad \bullet \; (\text{Obj}'(d, A) = \text{Obj}(d, A) - \{obj\}) \\ & \qquad \wedge \; (\text{Subj}'(d, A) = \text{Subj}(d, A) + (\{d\} \times obj)) \quad . \end{aligned} \qquad \textbf{(GSS7.1)}$$

As a result, the decision-makers are free to differ on the valuation once it is part of the *Subjective* set.

For completeness, the process of soft-coating itself involves first making a hard evaluation soft (GSS7.1) and then changing its value to other than it was in its previous status (along the same scale). This may be expressed as follows:

$$\exists \mathrm{SoftCoat} \bullet \mathrm{SoftCoat} = \mathrm{ChangeEvalValoMakeSoft}. \qquad (\textbf{GSS7.2})$$

ChangeEvalVal has already been defined in GSS5.3.

5. Utility as a Framework

Once formalised, the set of requirements can now be utilised as a framework for evaluation of any proposed eBPN support system solution and for the development of new ones. Both aspects are demonstrated in the following sub-sections.

5.1 Evaluation of Existing E-negotiation Systems

A major utility of this formalised requirements framework is that it allows evaluation of the suitability of existing e-negotiation systems for the eBPN domain. Table 2 exhibits part of the evaluation performed in [42] of some state-of-the-art negotiation support systems. It demonstrates that while existing systems, overall, provide many of major features for eBPN strategy-support, individually they are deficient in significant areas. B&P, the collective work of [9] and [35], in particular is proposed as an eBPN-specific system. However, it lacks subjective strategy-support facilities. On the contrary, general e-negotiation systems such as INSPIRE [26] and the commercial system Smart Settle (www.smartsettle.com) lack in basic mechanisms to interface with extra-negotiation data while providing facilities for subjective multi-criteria analysis. Also, dynamic change of decision-making criteria is not supported.

This in turn is the basis of the hypothesis that there is a lack of a holistic approach in current e-negotiation system development. If the intention is to, for example, support negotiations involving both soft and hard decision criteria, then a holistic approach would require not only mechanisms to provide scoring for such criteria but also the ability to include them in the system in the first place. This is surely not due to the lack of technology but due to a flaw in the approach.

Table 2 . Summary of sample e-negotiation systems evaluation using requirements framework.

Requirements	B&P	*N*egoisst	INSPIRE	SmartSettle	Overall
Intermediate data-set	✓	×	×	×	✓
Extra-negotiation data allowed	✓	×	×	×	✓
Interoperable persistence	✓	×	×	×	✓
Dynamically extensible	×	×	×	×	×
Multiple views for single message	×	×	×	× ~	× ~
Custom mapping rules	✓	×	×	× ~	✓
Concurrent use of all soft & hard data	× ~	× ~	× ~	× ~	× ~
Dynamic changing of criteria set	×	× ~	×	×	×
Criteria relationship definition	✓	× ~	× ~	× ~	× ~
Soft-coating ability	×	✓ ~	✓ ~	✓ ~	✓ ~

Key: ✓= passes ×= fails ~ = details in [43]
Source: B&P = [9] & [36] jointly ; INSPIRE = [26]; *N*egoisst = [41]; SmartSettle = www.smartsettle.com

This summarized analysis should also underline the significant utility this framework offers in developing e-business processes. A more comprehensive analysis of the state-of-the-art is expected to be the subject of a forthcoming publication issuing from original findings available in . That should be vis-à-vis a broader requirements framework examining other negotiation system dimensions such as "protocol" and "object".

5.2 Development of New eBPN Approaches

This formalised framework should also provide the basis for development of new approaches to eBPN, even by simply extending existing systems or by combining features across them. This has also been demonstrated in [42] with the development of SEPNA (Soft E-Process Negotiation Approach) which essentially provides a more holistic and human-centric approach to eBPN.[8] While existing systems do make available many of the required human-centric facilities, the previous section demonstrates how the lack of a holistic approach has meant that the utility of certain features is mitigated due to the non-existence of others. Using this framework, SEPNA has been developed as a *holistic* human-centric eBPN approach.

The demonstrative implementation of the approach, termed *SEPNA-Sys*, has also been constructed. It uses modular XML-based data objects, explicit criteria mapping rules and a component implementing the multi-criteria decision-making method called Analytic Hierarchy Process (AHP) [38] to realise the dynamically adaptable and human-centric decision-support prescribed by SEPNA. Using the framework, it has been benchmarked against INSPIRE, SmartSettle and B&P and shown to viably fulfil the formalised requirements [42].

[8] A preliminary version of SEPNA is documented in (where e-business processes are abbreviated as e-processes).

6. Conclusion

This paper has highlighted the need to systematically identify the requirements for e-business process negotiation, as this is missing in the relevant literature. Only then can claims be made with regards to the adequacy of current candidate systems-based solutions to this problem. As part of a more general investigation into this issue, this paper documents an initial and important set of "general" strategy-support requirements for eBPN and presents them as a formalised system evaluation framework. The utility of such a framework has been demonstrated in the evaluation of existing e-negotiation systems. It has been shown how some current e-negotiation systems lack a holistic consideration of negotiation problems they intend to deal with. The idea of the framework as a basis for development of eBPN-specific solutions has been discussed, citing the instances of SEPNA and *SEPNA-Sys*. Future work is expected to focus on extending SEPNA to meet other requirements identified for strategy-support that are process-specific, such as modelling the impact of activity level-of-control negotiation and change-tracking.

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Appendix: Notation and Supporting Formalised Concepts

Non-standard Notation.

Table 1. Explanation of non-standardised notation [40]

Sybmol	*Description*
x:S	*x* is by definition an element/member of the set *S*
Pow (*S*)	Powerset (set of subsets of *S*)
Num	Cardinality of a set (number of members)
Dom (*R*)	Domain of the relation *R*
Cod (*R*)	Co-domain of the relation *R*
Def (*R*)	Definition domain of the the relation *R*
Ran (R)	Range of the relation *R*
Gr (*R*)	Graph of the relation *R*
$\Re$	Set of real numbers
Top	"*T* is such that *P* holds"; Substitute for parentheses. Left parenthesis is replaced by '?' and matching right parenthesis is eliminated. For example: the definition of a total function *f* may be expressed as $\forall x : \mathrm{Dom}(f) \bullet \exists y : \mathrm{Cod}(f) \bullet (x, y) \in \mathrm{Gr}(f)$. This reads as "For all x that is by definition a member of the domain of *f* it is such that there exists a *y* which is by definition a member of the co-domain of *f* such that (*x,y*) is a member of the graph of *f*.
R20R1	Composition of relations

General Supporting Formalised Concepts: The following concept definitions would apply globally to the requirements specification.

$$D = \{d \mid d \text{ is a human decision-maker}\} \quad . \tag{1}$$

$$A = \{a \mid a \text{ is a decision-alternative that needs to be ranked by } d{:}D\}. \tag{2}$$

$$AttribName = \{ n \mid n \text{ is a possible attribute name}\} \quad . \tag{3}$$

$$AttribVal = \{ v \mid v \text{ is a possible attribute value}\} \quad . \tag{4}$$

$$PossAttrib = \{x \mid \exists n : AttribName, v : AttribVal \bullet x = (n, v) \vee x = (n)\} \quad . \tag{5}$$

$$NegMsg = \{ m \mid m \subseteq PossAttrib \} \quad . \tag{6}$$

$$Scale = \{scale \mid \exists d : D \bullet \exists \mathrm{Order} : \{d\} \times I_{scale} \text{ a } scale\} \quad . \tag{7}$$

The set of scales that at least one d:D can perceive a ranking for, given that I_{scale} is the index set for scale:Scale. For a discrete countable scale:Scale then n=Num(scale) I_{scale} = {1,2,…,n} expressing a descending order of ranking (i.e. 1 is highest and n is lowest). If scale:Scale is a continuous set (e.g. when a sub-set of real numbers are used as a scale), then I_{scale} = [0,1] and this is in descending order. The issue to note is that Scale enables ordering of preferences to be described.

$$Evaluation = Objective + Subjective \tag{8}$$

$$Objective = \{obj \mid \exists scale : Scale \bullet obj : A \text{ a } scale\} \quad . \tag{9}$$

This is the set of all objective evaluations which maps an alternative on to a scale in manner independent of the decision-maker.

$$Subjective = \{subj \mid \exists scale : Scale \bullet subj : D \times A \rightarrow scale\} \ . \tag{10}$$

Subjective evaluations are dependent on *d:D* performing the evaluation.

$$\text{Eval} : D \times \{A\} \text{ a } \text{Pow}(Evaluation) \ . \tag{11}$$

Eval(*d,A*) is the sub-set of *Evaluation* chosen by any *d:D* in deciding over *A*.

$$\text{Obj} : D \times \{A\} \text{ a } \text{Pow}(Objective) \ . \tag{12}$$

Obj(*d,A*) is the sub-set of *Objective* that any *d:D* chooses in deciding over *A*.

$$\text{Subj} : D \times \{A\} \text{ a } \text{Pow}(Subjective) \ . \tag{13}$$

Subj(*d,A*) is the sub-set of *Subjective* that any *d:D* chooses in deciding over *A*.

$$PossRanking = \{\text{Ranking} \mid \exists q \leq \text{Num}(A) \bullet \exists Rank = \{1,2,...,q\} \bullet \text{Ranking} : Rank \text{ a } A\} \ . \tag{14}$$

The set of all possible rankings and/or short-listings that can be derived from *A*.

$$DecSuppPro = \{proc \mid \forall d : D \bullet proc : \text{Pow}(\text{Eval}(d, A)) \rightarrow PossRanking\} \ . \tag{15}$$

The set of decision-support processes that maps the decision-maker and set of alternatives to a PossRanking. If proc:DecSuppPro is provided with Eval(d, A)then it will produce a ranked list of the alternatives. As the list can be shorter than the actual number of alternatives, it may also serve as a short-listing process.

$$\text{DSPRel: } DecSuppPro \text{ a } CompRel \bullet (\text{DSPRel}(proc) = compRel \wedge (proc = R_n \circ\circ\circ R_2 \ R_1) R \Leftrightarrow compRel = \{R_1, R_2 \ldots . R_n\} \tag{16}$$

It is therefore the function that returns the set of relations that a proc:DecSuppProc is a composite of.

$$FuncMapIn = \{f \mid \exists scale : Scale \bullet f : PossAttrib \times Evaluation \rightarrow scale \bullet f(x, eval) = s \Rightarrow s \in \text{Cod}(eval)\} \ . \tag{17}$$

This is the set of functions that produce values for evaluations from possible attributes. These can potentially be included as the value of an alternative for a given eval:Evaluation. Therefore a function which derives the quality rating of 'Good' from a negotiation attribute (QoS_Guarantee, 95%) is a member of FuncMapIn.

GSS1 - Supporting Formal Concepts.

$$\text{SoftSysRel: } SoftSys \text{ a } SoftSysCompRel \quad (18)$$

$$\bullet(\text{SoftSysRel}(s) = softRel) \wedge (s = R_n \text{ o} \ldots \text{o} R_2 \text{ o} R_1)$$

$$\Leftrightarrow softRel = \{R_1, R_2 \ldots R_n\} \quad (19)$$

Hence, a software system (i.e. s:SoftSys) is modelled as as a composite relation. SoftSysCompRel is thus the set of all the relations s is a composite of. (19) is meant to include functions that can potentially be built as extensions to existing software (i.e. "wrapper" components).

GSS6 – Supporting Formal Concepts. A set of possible operations is assumed that when applied to an evaluation result in modification of its value on the same scale:

$$PossEvalOps = \{evalOp \mid evalOp : Evaluation \rightarrow Scale$$

$$\bullet evalOp(e) = s \Rightarrow s \in \text{Cod}(e)\} \quad . \quad (20)$$

Also assumed are operations that combine sub-criteria to form super-criteria:

$$PossEvalCombs =$$

$$\{evalComb \mid evalComb : Evaluation \times Evaluation \rightarrow Evaluation \quad (21)$$

$$\bullet evalComb(e_1, e_2) = e_3\}$$

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Abstract

Inter-organisational processes constructed and operated in a business-to-business e-commerce context ("e-business processes") have received much focus in the recent literature on workflows. However, the problem of supporting e-business process negotiation (eBPN) remains under-explored. This paper reports on a novel investigation into this area. Though the research is still in its initial stages, significant findings can already be reported. In this paper, an analysis and formal representation of a set of electronic negotiation (e-negotiation) system requirements for the eBPN domain is documented. This contribution should eventually lead to a generic framework for more objective and efficient evaluation of e-negotiation systems, or their sub-systems, vis-à-vis this problem domain. The set of requirements pertains to "general" negotiation strategy support, as opposed to "process-specific" strategy support. Despite this limitation of scope, a major shortcoming in current e-negotiation systems is identified using the formalised requirements framework: the lack of a holistic approach. Also noteworthy is the use of other e-negotiation evaluation frameworks (e.g. the Montreal Taxonomy) in the derivation of the requirements set. Motivated by the above findings, further work on a new and more holistic eBPN approach called SEPNA is currently underway and this is briefly discussed here.

Keywords: inter-organisational workflow, e-business, electronic negotiation, decision-support systems, Montreal Taxonomy

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