IET Software

Review Article

Systematic literature review on intent-driven systems

ISSN 1751-8806
Received on 19th September 2018
Revised 24th January 2020
Accepted on 13th March 2020
E-First on 14th May 2020
doi: 10.1049/iet-sen.2018.5338
www.ietdl.org

Johan Silvander[1] ✉, Krzysztof Wnuk[1], Mikael Svahnberg[1]
[1]Software Engineering Research Lab Sweden, Blekinge Institute of Technology, Karlskrona, Sweden
✉ *E-mail: johan.silvander@bth.se*

Abstract: An intent-driven system is a compositional system of human actors and machine actors. The aim of intent-driven systems is to capture stakeholders' intents and transform these into a form that enables computer processing of the intents. Only then are different machine actors able to negotiate with each other on behalf of their respective stakeholders and their intents, and suggest a mutually beneficial collaboration. The aim is to find existing methods/techniques which could be used as building blocks to construct intent-driven systems. This is used to provide insight into what is needed to enable intent-driven systems with the help of these methods/techniques. As a part of a design science study, a Systematic Literature Review is conducted. The existences of methods/techniques which can be used as building blocks to construct intent-driven systems exist in the literature. How these methods/techniques can interact in order to enable realisations of intent-driven systems is not evident in the existing literature. The synthesis shows a need for further research regarding the semantic interchange of information, actor interaction in intent-driven systems, and the governance of intent-driven systems.

1 Introduction

The ongoing digitalisation demands from software-intensive companies increased business flexibility, predictive capability, and flexible architectures [1]. In the Telecom industry, this change is clearly visible with the advent of the fifth-generation network solutions that are going to be delivered as intent-driven systems capable of predictive analysis, enable massive connectivity, and provide open application programming interfaces for big data and cloud. Intent-driven networks predict faults and proactively optimise performance to deliver possible repairs [2]. The main carrier of value in these networks is software; we consider these companies as value networks.

The system studied in our previous work [3] is a business studio for a Business Support System (BSS) which supports the actual execution of an enterprise's business and the intended changes to this execution. The BSS is delivered as a product or a service, including configuration, monitoring and governance support. The BSS can be used in different business areas, for example charging, billing, customer relationship management, partner relationship management, product management, order management, etc. The next-generation BSS from Ericsson shall support the idea of continuous business-requirement engineering, where an intent-driven system is one of the cornerstones.

The goal with the research questions is to find out methods and techniques which can be used as building blocks of intent-driven systems are covered by the literature, as well as the interactions between the methods and techniques. The paper provides insight into what is needed to enable intent-driven systems with the help of these methods/techniques. The results may be used by practitioners who want to understand what exists and what is missing when constructing intent-driven systems. Researchers may find areas where gaps for realising intent-driven systems have been identified.

The remaining of this paper is organised as follows. In Section 2, the background and related work are presented. The research design and the research methods are presented in Section 3, and the execution results and analysis thereof are presented in Section 4. The results are further discussed in Section 5, and conclusions and future work are presented in Section 6.

2 Background and related work

Enterprises in a value network can be seen as parts in a compositional system composed of hierarchies of parts, with these parts themselves being meaningful entities, and being reusable in meaningful combinations' [4]. The construction of a compositional system requires methods to achieve a holistic collective benefit through the individual systems' participation and cooperation when each system adopts to a solution that maximises its own self-interest [5].

The actors in a compositional system may be humans or machines. By using software agents as machine actors, enterprises can support their continued demand for change, inject further intelligence into enterprises, and simplify the environment for both customers and employees [6]. Software supporting an enterprise's business, also known as a BSS, needs to support the correlation of activities between actors as well as influence the activities based on knowledge about the compositional systems the enterprise acts in.

In our previous work [3], BSS and its BSS studio were our focus. We introduced the ideas of intent-driven systems, and introduced Pask's conversation theory [7] as a model to describe intent-driven systems. We defined a *context frame* as the total domain information for a specific domain an actor has obtained. The interaction between context frames are describes as interactions between different viewpoints. The handling of different viewpoints requires governance and semantics. The interactions require the interchange of semantics in order to create an understanding between the different interacting actors. We concluded the need for further investigations about how continuous definition and execution of a business intent‘s life cycle in an enterprise and its value networks can be achieved, and to find a meta-model supporting a context frame aware realisation of a business intent's life cycle in a compositional way. Below we describe our gained understanding of what is required by an intent-driven system and why it is required.

In this paper, we continue to view an enterprise as a hierarchical line-of-command structure in which business rules at the top steer, align and control the activities and behaviours further down in the structure. Business rules also steer all behaviours in a BSS, in pursuit of the goal of creating and maintaining a successful business.

We define intent as a subject or type of possible behaviour, i.e. something that can be interpreted to have significance. Any actor can have intents. When an actor publicly declares an intent in a

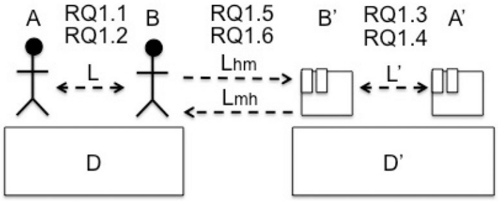

Fig. 1 *Mapping of RQs to the intent-driven systems model*

certain context, it becomes a stated intent. A stated intent could be a declaration of capabilities an actor promise to provide, or a requirement an actor try to impose on another actor. A decision about whether an actor has kept its promise or not, can be done by the promising actor as well as any actor which is observing the behaviour of the promising actor.

The difference between a business rule and a business intent is a small shift of perspective. A business rule is static and states what to do in a given situation, while a business intent states the desired or optimal outcome of a given situation. An intent can range in complexity from an atom intent to an algorithm of intents that combines a set of sub-intents. An atom intent on one level is likely to fan out into several intents on a lower level. During the interaction about an intent the actors have to prove their understanding of the intent in order to gain a common understanding and knowledge about the intent. This interaction can evolve over several steps and might re-shape the original intent. This requires an architecture that can support context awareness in a compositional way. We define this type of system as intent-driven systems.

Intents must be formulated for both human and machine consumption to facilitate automation in a BSS. The level of automation, of decision and action selection, depends on the involved components capabilities and rights of taking decisions and performing actions. Parasuraman *et al.* [8] present a scale of the 'levels of automation of decision and action selection' ranging from 1 (The computer offers no assistance; a human must take all decisions and actions.) to 10 (The computer decides everything, acts autonomously, ignoring the human.). In order to control and manage these capabilities and rights, governance views are needed.

The architecture must support an intent-driven system to optimise itself by continuously compare and evaluate both business outcomes and its own capabilities. The results may require continuous adaptions of a business intent's definition and execution. This requires components with a high, but adaptable, level of automation. To our knowledge, no such BSS exists in the industry today. Despite industrial relevance, little research has been conducted in the area of intent-driven systems and how software companies can be supported in building and managing these systems.

With the help of a simple example [9], we describe how an intent-driven system supports the interaction between humans and machines in order to evaluate and learn how to create a common understanding regarding the realisation of business intent. Since an intent-driven system supports the idea of compositional systems, the common understanding of a business intent will be divided into different domains. Each domain will have its own domain knowledge and context awareness regarding a business intent or its sub-intents. The process of creating a common understanding about a business intent between domains, and inside a domain, is highly automated with the help of software agents that negotiate on behalf of their stakeholders. In order to realise a business intent, an intent-driven system offers highly automated support to the various stakeholders, by suggesting and governing the needed decisions. The self-adaptive nature of an intent-driven system is used to evaluate and learn how to optimise its own capabilities, and the business outcome, with respect to a business intent and its sub-intents.

The aim of this study is to find methods/techniques needed to realise a robust, but still flexible, software architecture for an intent-driven system. The intent-driven system shall be used to realise a BSS and its business studio. The study is performed during the time the subjects were investigating and elaborating the requirements needed to support the planning and monitoring of business intents.

3 Research design and methods

We decomposed our goal to summarise the state of the literature about the techniques and methods used to build intent-driven systems into two research questions, outlined below. The first research question is to find evidence in the literature of methods/techniques supporting intent-driven systems, i.e. supporting the construction, expressing, and validation of business intents. The second research question is to find evidence in the literature on how the different methods/techniques could be used together to enable realisations of intent-driven systems.

RQ1: What methods/techniques supporting intent-driven systems have been presented in the literature?

According to Benaroch [10], the following three parts are needed when representing knowledge:

- Construct – how to construct the business intents,
- Express – how to express business intents in a match-able way, and
- Validate – how to ensure the business intents are actually met by a particular configuration.

We used Benaroch's findings together with Pask's conversation theory [7] to divide RQ1 into sub-questions. The mapping of the sub-questions to the intent-driven systems model is shown in Fig. 1.

Two key components in Pask's conversation theory are language and domain. A language L is defined as

> 'L may be a natural, written or spoken, symbolic language, but it need not be. It may be a system of symbolic behaviours such as dance or actions such as key pressing. It may be formalised, as in, mathematics and higher-level programing languages, but it need not be. It must, however, have many of the qualities of a natural language, with possibilities to express and interpret commands, questions, answers, obedience's, explanations, or descriptions.' [11].

A domain D could be described as:

> 'A domain is a collection of topics, and a topic is essentially a relation. This may be a very concrete relation (a relation between alphabetic characters and the keyboard positions in typewriting), or it may be an abstract relation (a relation between smugglers and the countries they operate in): To learn or solve a problem is to 'bring about' such a topic relation.' [11].

In Fig. 1, we see how two stakeholders, A and B, interact with each other via a language L, regarding domain D. Stakeholder B expresses its intents, which are communicated to Component B′ via a language *Lhm*. Component B' interprets the intents, and the results are presented to Stakeholder B in language *Lmh*. The components are communicating with each other over language L′, regarding the domain D′. The indirect interaction between A and, B via B′ and A′, is not shown in the picture. Since the communication between A′ and A uses the same mechanisms as the communication between B′ and B, this communication is covered by RQ1.5 and RQ1.6.

To the left in Fig. 1, the following sub-questions are found:

RQ1.1: What methods/techniques have been proposed to express and construct human actors' intents?

RQ1.2: What methods/techniques have been proposed to validating the human actors' intents?

To the right in Fig. 1, the following sub-questions are found:

RQ1.3: What methods/techniques have been proposed to express and construct machine actors' intents?

RQ1.4: What methods/techniques have been proposed to validating the machine actors' intents?

Table 1 Inclusion/exclusion criteria

ID	Inclusion/exclusion parameter	Inclusion/exclusion criterion
IC1	Year	2000–2018 (inclusive)
IC2	Language	English
IC3	Document type	Conference paper, Article, Review
IC4	Subject area	Any of the following subject areas: Multidisciplinary, Economics, Environmental Science, Social Sciences, Arts and Humanities, Psychology, Engineering, Mathematics, Business, Decision Sciences, or Computer Science.
IC5	Information structure	Full text available in English
EC1	Relevance of the contribution to intent-driven systems	No theory describing a building block of intent-driven systems.
EC2	Redundant information	A paper with the same information from different sources or an updated version(s) of the paper exists. The latest version is kept.
MSC	Main selection criterion	Explained in Section 3.2.1.

Table 2 Initial keywords for the pilot study

Group	Terms
K	('intent' OR 'intention' OR 'vision' OR 'strategy' OR 'strategies' OR 'goal' OR 'tactic' OR 'objective')
L	('driven' OR 'motivated' OR 'focused')
M	('system' OR 'solution' OR 'realisation' OR 'realisation')
N	('govern' OR 'guide' OR 'control')
O	(('decision support' AND 'DSS') OR 'behaviour driven' OR 'feedback observation')

In the middle of Fig. 1, the following sub-questions are found:

RQ1.5: What methods/techniques have been proposed for matching intents expressed by human actors and intents expressed by machine actors?
RQ1.6: What methods/techniques have been proposed for validating the matching of intents expressed by human actors and intents expressed by machine actors?

To find proposals in the literature which enable realisations of intent-driven systems based on the answers from RQ1.1 to RQ1.6, we formulated the following research question:

RQ2: What proposals to enable realisations of intent-driven systems have been presented in the literature?

Together with domain experts from Ericsson, we used Fig. 1 and our previous work (described in the third paragraph in Section 2) to find aspects needed to enabling realisations of intent-driven systems. These aspects were used to evaluate if the methods/ techniques found in RQ1.1–RQ1.6 can be used together, as described in the literature, for enabling realisations of intent-driven systems.

Semantics is the aspect making it possible to obtain the Languages in Fig. 1.

Interchange of semantics is the aspect making it possible for actors to collaborate on an intent with the help of their individual context frames.

A governance aspect is needed in order to provide knowledge about the correlation factors, support intents' life cycles, and the correlation between intents. Governance refers to 'The discipline of monitoring, managing, and steering a business (or IS/IT landscape) to deliver the business outcome required [12]'. The governance supports the configuration, simulation, and feedback of changes to existing business intents as well as for the introduction of new business intents.

The aspects of actor interaction have to be considered in order to enable the realisations of intent-driven systems. Pask's conversation theory supports the interaction between an arbitrary number of actors. The actors could be human actors as well as machine actors. These aspects of actor interaction have to be considered.

3.1 SLR methodology

In order to answer the research questions, we conducted a Systematic Literature Review. The used methodology is based on Kitchenham and Charters' guidelines [13].

Since the ideas span a wider area than computer science, we selected SCOPUS as the primary source, with subsequent additional searches in ISI/Web of Science, ACM, and IEEE Xplore. The study selection criteria and data extraction properties were created based on the research questions, strengthened by discussions with domain experts at Ericsson. To further mitigate the risk of author bias, a researcher external to the project was invited to check the results.

3.1.1 Pilot study: We piloted the systematic review procedure in order to establish a common view of the selection criteria, and develop a mature data extraction procedure. We decided to use IC1–IC3 in order to find relevant papers from an academic point of view (the exclusion criterion and the inclusion criteria are listed in Table 1). Since intent-driven systems include more subject areas than computer science, we decided to use IC4 to broaden the search to include relevant subject areas.

The inclusion criteria in Table 1 were applied on a trial search against SCOPUS, where 1227 papers where found. After applying IC1–IC3, 1052 papers where retrieved. IC4 was applied to the retrieved set, which left 795 papers for primary study selection. The number of papers that were regarded as primary studies for full-text reading was 106. We used a search string that is composed of terms grouped together as K, L, M, N and O and executed as K AND L AND M AND N AND O. The keywords were obtained from the research questions, and through brainstorming with domain experts from academia and the industry. The groups and their terms are found in Table 2.

From the search, 40 papers were randomly selected. The first author and a domain expert individually assessed titles and abstracts of the selected papers. The assessment showed a high consensus between the main author and the domain expert (Cohen's Kappa coefficient equal to 0.754). Discussions were performed on papers for which no consensus was found during the assessment. The discussions led to a higher consensus between the main author and the domain expert.

The result of the pilot indicates that the search terms produce relevant hits, and that the initial choice of search database was reasonable. Thus, we decided to continue with the main search in additional sources and with amended search terms as described in the sections below.

In order to find new keywords, papers regarded as primary studies for full-text reading were selected. The authors' keywords were extracted from the selected papers. We selected the keywords to be part of the search string in collaboration with domain experts.

The new keywords helped to form the final search strings (Table 3).

In order to develop a mature extraction procedure, we used the set of relevant papers found in the SCOPUS search. From each subject area (Table 1), we selected the first two papers. Based on the initial data extraction protocol, each researcher applied coding on the selected papers. For each of the papers, we compared the extracted data with the content in the paper and the codes being used. As a result, we changed some of the data extraction questions in terms of wording, added new questions, and re-ordered the questions. The final data extraction protocol is available in Table 4.

During the pilot, it was decided to add exclusion criteria 1 and 2. We based EC1 on RQ1.1–RQ1.6.

3.1.2 Refining research question and/or search strings: During the pilot study, the papers selected as primary studies for full-text reading were used to find new keywords for the search string. We selected the keywords to be part of the search string in collaboration with domain experts.

3.1.3 Search string: The research questions are searching for methods/techniques which can be used as building blocks for intent-driven systems. The search string is composed of terms grouped together as K, L, M, N, and O and executed as K AND L AND M AND N AND O. The groups and their terms are found in Table 3. The new keywords found during the pilot study were added to group O. The other keywords were obtained from the research questions, and through brainstorming with domain experts from academia and the industry.

3.2 Inclusion/exclusion criteria

In this section, we describe the criteria and processes, which are used to determine if a paper should be accepted as a primary study.

3.2.1 Main selection criterion: The main selection criterion for inclusion as a primary study is the existence of explicitly described methods/techniques, which answer RQ1. The main criterion should be observable in the title or abstract. During the full-text reading of a selected paper, the main criterion should be described/explained in the text. The inclusion and exclusion criteria are described in Table 1.

3.2.2 Search strategy: To cover a wide range of disciplines, we use Scopus, ISI/web of science, ACM digital library, and IEEE Xplore. To get the initial set of papers, we followed the following process. Each selected resource was searched using the search string (Table 3) with IC1–IC4 applied directly in the selected resource's search engine. The retrieved papers were filtered from duplicates, EC2, with the help of a reference management system named Mendeley. Finally, EC1 was applied according to the main selection criterion. The remaining papers are part of the primary study for full-text reading. Reviews were analysed based on their unique contribution, i.e. not based on their cited papers. The primary studies were obtained by applying IC5, EC1, and EC2 according to the main selection criterion.

3.2.3 Quality assessment criteria: Academic quality assessment is performed by applying the inclusion/exclusion criteria. We use the additional quality assessment to assess the level of contribution from each article towards intent-driven systems. A method/technique is regarded as *useful* for intent-driven systems; if the described theory could be used outside the paper's specific solution or if the paper enables a realisation of an intent-driven system. By combining ID1 and ID2 from the final data extraction protocol in Table 4, we created the quality assessment criteria as described below.

The relevance of the papers is judged according to the following criterion (where articles matching level 1 are deemed as being most useful, followed by articles matching levels 2 and 3 (least useful). Articles not matching any criterion level are deemed as not useful)

Level 1: The methods/techniques described are in the focus of the paper and articulated in the study. The described theory might be used as a building block of intent-driven systems.
Level 2: The methods/techniques described are not in the focus of the paper and not fully articulated in the study. The described theory might be used as a building block of intent-driven systems.
Level 3: Methods/techniques are described in theory, and the theory might be used as a building block of intent-driven systems.

3.2.4 Data extraction process: A reference management system was used to import the papers. The selected papers were then imported to the Atlas.ti tool. Atlas.ti supports flexible coding structures, report generation, and code-based filtering functions. The coding is done on the text itself and a coded text section can contain subsections with different codes. This feature makes it possible to drill-down and further detail the coding.

We used the IDs from the final data extraction protocol (Table 4) as the base for a code taxonomy. If alternatives for the answer to a question was present in the data extraction protocol, these alternatives were given numbers and were used in the code taxonomy. Answers to questions with no alternatives were coded and became a part of the taxonomy.

The coding was done as an iterative process. We applied codes to a set of fifteen papers. If new codes were introduced or doubts about the coding existed, a discussion between the researchers was performed. This process continued until all papers had been read. The papers from the former sets were included in new iterations. Coding and re-coding were applied to papers when the understanding of the content improved.

Since the coding is performed on the text itself, a paper can have several and contradicting answers to the same question. To find the contribution of each paper, a report generation function was used. In the report, it is possible to view the marked text, which is useful when discussions about a certain coding were needed.

It is possible to generate reports regarding all the papers. However, we found it more intuitive to use a filtering function called network views. The network views were based on the extraction codes in Table 4. We added the extraction codes to the view. With the help of the tool, the papers related to the codes were imported. The codes and the papers became nodes in the graph, and the relations between a paper and a code became edges in the graph. By applying filters we could find only the papers related to a specific code, or only the papers related to a set of codes. These filters gave us the information provided in Table 5, and the possibility to find the commonalities described in Section 4.2.5.

3.2.5 Review protocol: The review protocol aims to reduce the potential researcher bias and to enable replication of the review in the future. The protocol was evaluated by an independent researcher who is experienced in conducting systematic literature reviews. According to the researcher's feedback and our own gathered knowledge during the process, we iteratively improved the design of the review protocol. Each step in the protocol was performed in iterations, and a re-evaluation of the protocol was performed as part of the iteration. The re-evaluations were discussed and decided upon together with the researcher.

The review protocol is maintained in the reference management system. This includes the IC5, EC1, and EC2 (see Table 1). The IC1–IC4 were handled by the search engine and are not part of the protocol.

The review protocol is created with the help of a tag structure and a folder structure. The folder structure is actually implemented as a built-in tag structure by the reference management system, which means that each paper can belong to several folders. The folder structure is used to expose the state a paper is in during the decision process of accepting it as a primary study. The tag structure is used to tell which criterion/criteria prevented a certain paper to reach the state of a primary study (see Table 1). If an

Table 3 Search strings for the main study

Group	Terms
K	('intent' OR 'intention' OR 'vision' OR 'strategy' OR 'strategies' OR 'goal' OR 'tactic' OR 'objective')
L	('driven' OR 'motivated' OR 'focused')
M	('system' OR 'solution' OR 'realisation' OR 'realisation')
N	('govern' OR 'guide' OR 'control')
O	(('decision support' AND 'DSS') OR 'behaviour driven' OR 'negotiation driven' OR 'collaboration driven' OR 'feedback observation' OR 'adaptive policy' OR 'adaptive policies' OR 'adaptive rule' OR 'adaptive decision' OR 'adaptive visualisation' OR 'adaptive visualisation' OR 'composition optimisation' OR 'composition optimisation')

Table 4 Data extraction protocol used for RQ1:1–RQ1:6

Code	ID	Question
Relevance(1)	1	What is the relevance of the contribution to IDS? Select one 1. Describes a (validating) method in the intended context of IDS. 2. Describes a (validating) method that could be used in IDS.
Contribution(2)	2	How could the contribution be used in IDS? Select one 1. As a contribution to a framework 2. As a contribution to a theory 3. As a contribution to background material The area of the contribution.
Standards and Theories(3)	3	Is the contribution to the (validating) method based on a standard/academic theory? Yes (which), No, Not stated
	4	How is the standard/academic theory presented? Used, defined
Limitations(4)	5	Are there any limitations in the suggested contribution to the (validating) method? Size, Distribution, Concurrency, Sharing, Others, Not stated
	6	Is the contribution to the (validating) method targeting a specific domain? Yes (which), No, Not stated
Role support(5)	7	What types of actors are supported? Parties (organisations, individuals), Services, Resources, Not stated
	8	How are the actors represented? IRL, by software (agents, simulation, etc.), by data, Not stated
Context support(6)	9	How are the definitions of contexts supported? 'Blank sheet', specific source (which), generic sources, Not stated Partitions supported, overlapping partitions supported, Not stated
	10	How is the governance of context definitions supported? Fixed after definition, Merge of contexts (full or partial), Split of contexts, No support, Not stated
	11	How are the combinations of actors, views and contexts supported? One view of one context (one of several actors), Several views of one context (one or several actors), Several contexts (one or several actors), Not stated
	12	How are the validation of combinations of actors, views and contexts supported? One view of one context (one of several actors), Several views of one context (one or several actors), Several contexts (one or several actors), Not stated
Tools and Technology(7)	13	What technologies are used for constructing the contribution to the (validating) method? Known technologies (which), New technologies (used by others), Not stated
	14	Are any specific tooling required for the construction of the contribution to the (validating) method? Yes (which tools), No, Not Stated

explanation of the decision was regarded as needed, a note was attached to the paper.

Every satisfying paper IC1–IC4 was tagged with two tags. One of the tags is representing the subject area (see Table 1). The other tag is representing the primary source (one of SCOPUS, ISI/Web of Science, ACM or IEEE Xplore).

4 Results and analysis

The results of the search are shown in Table 6.

The individual research questions are evaluated one by one, and in the end, an intent-driven system perspective is discussed. The information in the papers is categorised according to the quality criterion in Section 3.2.3. Table 5 lists the articles fulfilling the three quality criterion levels. For papers passing criterion level 1 (i.e. deemed most useful for the understanding and construction of intent-driven systems), the theories/methods/techniques are listed. Individual comments on the primary studies are available in Tables 7–9.

4.1 RQ 1

Table 5 shows the 17 articles passing quality assessment criteria level 1. Together, the listed theories/methods/techniques from the articles passing level 1 of the quality criterion constitute the answer to RQ1.

Most contributions in this study are found in the area of expressing and validating human actor's intents (RQ1.1 and RQ1.2, to some extent RQ1.5 and RQ1.6, were covered). The main focus is on one context frame. The validating methods/techniques of the

Table 5 Mapping of papers to RQ1's sub-questions

RQ	Level 1	Level 2	Level 3	Level 1 Theories/Methods/Techniques
1.1	[14, 15] [20, 21] [26, 27] [30, 31] [34, 35]	[16, 17] [22, 23] [28, 29] [32, 33]	[18, 19] [24, 25]	Multi-Criteria Decision Analysis, MASs, Negotiation protocols, Structured argument capturing, Bayesian theories, Decision Map and Discrete Wavelet Transformation, Conditional Preference Networks.
1.2	[20, 29] [34]	—	[24]	Bayesian theories,, Conditional Preference Networks and Multi-Criteria Decision Analysis.
1.3	[36]	[16, 37] [40, 41] [29, 44] [33, 47]	[38, 39] [42, 43] [45, 46] [48, 49] [25]	Semantic technology based on WSDL.
1.4	[29, 40]	[44]	[38, 45] [46, 48]	Bayesian theories and Genetic algorithms.
1.5	[50]	[37, 51] [54, 55]	[52, 53] [56, 57] [58, 59] [25]	Algorithm to reason about most preferred outcome for a compositional system.
1.6	[37, 60] [51]	[55]	[53, 57] [58]	PCA with or without neural networks, Reinforcement learning

Table 6 Included and excluded studies

Activity	SCO	ISI	ACM	IEEE
Keyword search	1314	14	130	5623
Excluded due to inclusion criteria 1 or 2 or 3	*−239*	*−4*	*−21*	*−1138*
Retrieved papers	1075	10	109	51
Excluded due to duplicates or inclusion criterion 4	*−260*	*−10*	*−7*	*−3*
Primary Study Selection	815	0	102	48
Excluded due to exclusion criterion 1	*−703*	*0*	*−87*	*−45*
Primary study for full-text reading	112	0	15	3
Excluded due to inclusion criteria 5 or exclusion criterion 1 or 2	*−80*	*0*	*−13*	*−2*
Remaining primary studies	32	0	2	1

Since IEEE Xplore does not provide good search capabilities for large search strings a new method was developed. The search string was divided into two sets and these sets where, after duplicate removal, joined to find the result set. The resulting set contained 51 papers as indicated in the table. Before the join was performed 4485 papers were obtained. IC4 could not be obtained within IEEE Xplore.

transformations presented in the literature (RQ1.2, RQ1.4, and RQ1.6) have tight coupling between the realisation and the information in each method/technique. The contributions covering reusable capabilities and characteristics of software components (RQ1.3 and RQ1.5) do not consider different context frames.

Below, we discuss each of the sub-questions in further detail.

4.1.1 RQ 1.1: When looking at the methods or techniques to express and construct human actors' intents that pass quality assessment level 1, most of the studies provide theories with experiments, except from Bykov *et al.* [15], who presents the results from an industrial case study. The dominant topic among the included papers is decision making and multi-criteria analysis, in terms of decision support system (DSS) for process improvement, realised with the help of multi-agent systems (MASs) [15, 26] that could support distributed planning [27] or handle heterogeneous information [21]. Castro-Schez *et al.* [20] use fuzzy logic to acquire information from a human actor in the multi-criteria decision analysis scenario. Adabi *et al.* [14] focus on introducing flexibility into the negotiation process by suggesting a protocol to relax the decision to complete a deal in the presence of time pressure that also handles non-reasonable behaviour. Zhan *et al.* [35] use fuzzy reasoning in order to create policies and negotiate between the actors while Lowrance *et al.* [30] offer a structured argument template to support argumentation and negotiation. Finally, two papers highlight the need for improved visualisations that can support multi-criteria decision making, either by compressing data without losing the details needed for analytical purposes [31] or querying conditional preference networks [34].

Looking at the papers that do fully articulate the proposed methods for expressing and constructing human actors' (level 2), all papers present a theory and an experiment. Dorneich *et al.* [22] focus on the mental state of humans utilising neural networks, while Memon *et al*. [28] are using natural language processing. Bollati *et al.* [16] focus on handling changes supporting model transformations and Topcu [33] uses deliberative coherence theory to handle changes in goals. Ren *et al.* [32] extend market-driven agents with negotiation capabilities, while Colloc and Sybord [17] combine MASs with different context frames. Hu *et al.* [23] focus on multi-criteria decision analysis, where the desire from one of the actors has to be correlated with the constraints to fulfil the desires of the second actor. Finally, Pan *et al.* [29] focus on inferring relevant but not directly observed information from partial information in a situation-specific context with the help of Bayesian theories to represent knowledge.

Four papers theoretically describe methods and techniques that can be used as building blocks of intent-driven systems (level 3) [18, 19, 24, 25]. Baudry *et al.* [18] suggest combining Monte Carlo simulation with multi-actor multi-criteria analysis, while Kishore *et al.* [19] suggest integrating a MAS into a DSS. Larsson and Ibrahim [24] talk about policy formulation. At the same time, Wiesner *et al.* [25] advocate using natural language processing for requirements engineering, which highlights the same problems that need to be solved for intent-driven systems.

Table 7 Comments on papers passing criterion level 1 (part one)

Paper	Contributes to RQ	Comments
[14]	1.1	Theory combined with an experiment: A new fuzzy protocol for negotiations used by agents in a grid environment. The aim with the protocol is to achieve a flexibility to relax decision to complete a deal when faced with trading pressure. The main features of the protocol are: 'A more accurate consideration of the trading pressure.', 'The possibility to handle non-reasonable behaviour of negotiator agents' and 'The ability to handle multiple trading opportunities and market competition.'. The main features of the presented fuzzy protocol could be used to negotiate business intents between the involved actors. This supports RQ1.1.
[37]	1.6, (1.3, 1.5)	Theory combined with experiment: Methods to transform goals into policy configurations. These transformation methods are not disciplined specific. This will make it possible to use the same method independently of the policy discipline as well as supporting a policy configuration with heterogeneous policy disciplines. A case-based transformation approach was evaluated and two other approaches were discussed (static rules and policy table lookup). In order to be able to make use of the multi-dimensional information, the number of dimensions needed to be considered has to be reduced. Two-dimension reduction methods where presented, PCA and feature selection. The use of PCA to reduce and find suitable mappings between actor goals and component behaviour might be useful. This supports RQ1.6. Business level abstractions are done in order to map business goals to policies. As presented in the paper, the abstraction level seems to be on a too low level to qualify as business goals. The use of a case database as a knowledge base for the transformation model focus on policies according to IETF. This makes the paper not passing criterion level 1 as support for RQ1.3 and RQ1.5.
[15]	1.1	Theory combined with results from a real world case: Describes how a DSS for process improvement could be realised with the help of a MAS. The MAS combined with a knowledge representation model is used for simulations. This knowledge representation model is shown and discussed. The use of a MAS in order to do a simulation in a DSS supports RQ1.1.
[20]	1.1, 1.2	Theory combined with an experiment: Presents a solution to increase a DSS's efficiency when dealing with a great number of alternatives and criteria. This is done by using Multi-Criteria Decision Analysis combined with a functionality to explain the decisions taken. To acquire information from a human actor, fuzzy logic has been used. This makes it easier for the actor to express the information naturally. The Multi-Criteria Decision Analysis is broken down into a structure close to the Context Frame concept. How ever, the solution supports only one actor. This supports RQ1.1. The functionality to explain the decisions taken supports RQ1.2.
[21]	1.1	Theory combined with experiment: Presents a framework to support decision-makers in reasoning under uncertainty. The paper describes how to use Decision Maps to assist in Multi-Criteria Decision Analysis. The framework's strength is its possibility to handle heterogeneous information. The possibility to handle heterogeneous information supports RQ1.1.
[26]	1.1	Theory combined with experiment: Describes a DSS where one group of actors is using Fuzzy Multi-Criteria Decision Analyse and the other actors are modelled as agents (based on survey data) or a simulation (environment model). The DSS will support a decision-making process is a complex choice situation with multiple management objectives and multiple strategies that are under consideration. The possibility to support a decision-making process in a complex choice situation with multiple management objectives and multiple strategies that are under consideration supports RQ1.1.
[27]	1.1	Theory combined with experiment: Presents a framework for distributed planning in hierarchical structures with the help of a MAS and Multi-Decision Criteria Analyses based on a model approach. Requirements for a DSS based on this concept are proposed. Distributed planning in hierarchical structures supports RQ1.1. According to the paper MAS approaches are appropriate for enterprise management but there is a lack of appropriate semantics and ontologies.
[60]	1.6	Theory combined with experiment: Presents a method to define which learning action a person should have, based on earlier achievements. The method is based on the contextual multi-armed bandits framework. Two different algorithms are presented and evaluated. This supports RQ1.6, but the paper does not pass criterion level 1 as support for RQ1.5.
[30]	1.1	Theory combined with experiment: Presents a methodology for structured argumentation. The methodology is stated to be non-intrusive on an enterprise's existing analytic products and methods. The structured argument methodology consists of an argument template used to govern the analytic process structure and arguments, which is the instantiation of an argument template. Defining templates for a structure. The structure itself could be used to define different context frame. This supports RQ1.1.
[40]	1.4, (1.3)	Theory combined with experiment: Presents a way to improve the decision strategies for agents with the use of genetic algorithms. The method used to build the models is recursive in nature. Measure the fitness of an Agent in a MAS in order to improve the performance of new agents. This is done with the help of evolutionary mechanisms. This supports RQ1.4 but the paper do not pass criterion level 1 as support for RQ1.3.
[51]	1.6, (1.5)	Theory combined with experiment: Presents a method to define which policies to use to present information, based on earlier achievements, to solve complex reinforcement learning problems. The comparing and validation of the policies are done offline with the help of importance sampling method. PCA and neural networks are combined in order to solve the problems with finding relevant solutions. This supports RQ1.6 but the papers do not pass criterion level 1 as support for RQ1.5.

4.1.2 RQ 1.2: Only three studies clearly articulate methods or techniques for validating the human actors' intents on level 1. Castro-Schez *et al.* [20] claim that introducing functionality to explain the decisions taken helps to validate intents while Pan *et al.* [29] focus on to inferring relevant but not directly observed information from partial information in a situation-specific context with the help of Bayesian theories, as the underlying knowledge representation, as a way to validate intents. Xin and Liu [34] claim that graphical representation of preferences as conditional preference networks help in intent validation. No papers are identified on level 2 and only one study is identified on level 3. This study is about a process for policy formulation and policy options [24].

4.1.3 RQ 1.3: We identify 18 papers about expressing or validating machine actors' intents. Regarding expressing, only one paper is classified in level 1 category. Narock *et al.* [36] suggest that using PROV-N and W7 to create a service provenance

Table 8 Comments on papers passing criterion level 1 (part two)

Paper	Contributes to RQ	Comments
[36]	1.3	Theory combined with experience: Using PROV-N and W7 to create a Service Provenance Ontology, which could be used by service creators to supply all necessary provenance information of web services. Since the idea with provenance is to provide 'information about entities, activities, and people involved in producing a piece of data or thing, which can be used to form assessments about its quality, reliability or trustworthiness', this supports RQ1.3.
[29]	1.2, 1.4, (1.1, 1.3)	Theory combined with experiment: Presents a way to inferring relevant but not directly observed information from partial information in a situation-specific context with the help of Bayesian theories as to the underlying knowledge representation. This supports RQ1.2 and RQ1.4. How the needed context frame is described and added is not part of the paper. Neither is the construction of the rules. This makes the paper not passing criterion level 1 as support for RQ1.1 and RQ1.3.
[31]	1.1	Theory combined with experiment: Propose the use of Discrete Wavelet Transformation (DWT) in DSSs for event-driven enterprises. According to the paper, improvements of visualisation is achieved due to the DWT's ability to compress data without losing the details needed for analytical purposes. The possibility to visualise a huge amount of information in order to support actors' business intents supports RQ1.1.
[50]	1.5	Theory combined with experiment: Provides an algorithm that could be used to reason about the most preferred outcome for a compositional system both in terms of quantitative and qualitative preferences. The possibility to reason about preferred outcomes for a compositional system supports RQ1.5.
[34]	1.1, 1.2	Theory combined with experiment: This paper extends the possibility of querying a graphical model. Describes how to use a graphical model for representing preferences in the form of conditional preference networks. The paper extends the possibility of querying conditional preference networks. The ability to graphically express the preferences and the possibility to query the model for different desired decisions supports RQ1.1 and RQ1.2.
[35]	1.1	Theory combined with experiment: Describes an agent-based negotiation model for policy generation. The agents use fuzzy reasoning in order to create policies that are acceptable for self-interested stockholders. This supports RQ1.1.

ontology that could be used by service creators to supply all necessary provenance information of web services.

Eight papers do not fully articulate the presented methods or techniques on level 2. Three studies focus on MASs. Maione and Naso [40] use decision strategies for agents with the use of genetic algorithms, while Sousa *et al*. [47] use MASs to optimise resource allocation. Topcu [33] uses deliberative coherence theory to describe how agents can change according to the surroundings as well as to changes in goals. Two studies focus on transformations: goals into policy configurations [37] or model transformations [16]. Two studies suggest using Bayesian networks for supporting making decisions in stressful situations [41] or inferring relevant but not directly observed information from partial information [29]. Finally, Shirazi *et al.* [44] use simulation to validate the effect of new parameter settings with the help of information from the real environment.

Nine studies suggest theories that may be useful for intent-driven systems on level 3. Three studies look at digital policy management [38, 39], or policy-based management based on OWL-S [42]. Two studies focus on semantic web services for service negotiation [46, 48] while Shojaiemehr *et al.* [45] highlight the improvements needed for service negotiation. Pezzulo [43] presents the reason for different ways (and schools) to represent knowledge while Waled *et al.* [49] focus on how agents can find the required skill from other agents when needed. Wiesner *et al.* [25] highlight challenges in constructing cyber-physical systems.

4.1.4 RQ 1.4: Regarding papers that articulate methods and techniques for validating the machine actors' intents (level 1), Maione and Naso [40] present a way to improve the decision strategies for agents with the use of genetic algorithms and evolutionary mechanisms while Pan *et al.* [29] present a way to inferring relevant but not directly observed information from partial information in a situation-specific context with the help of Bayesian theories as to the underlying knowledge representation.

We identify one paper that does not fully articulate the methods for validating machine actors' intents (level 2). Shirazi*et al.* [44] are using simulation to validate the effect of new parameter settings with the help of information from the real environment.

Among the theories that may be used to help to validate the machine actors' intents and build intent-driven systems (level 3), we identify four studies. Shojaiemehr *et al.* [45] focus on improvements in service negotiation, while Bakshi *et al.* [38] focus on adaptive policymaking. The authors [46, 48] focus on creating or improving semantic enabled web services.

4.1.5 RQ 1.5: We find only one paper that articulates the methods used to match human and machine actor intents (level 1). Santhanam *et al.* [50] provide an algorithm that could be used to reason about the most preferred outcome for a compositional system both in terms of quantitative and qualitative preferences. The possibility to reason about preferred outcomes for a compositional system supports RQ1.5.

Four studies that do not clearly articulate methods or techniques for matching human and machine intents (level 2) are found. Beigi *et al.* [37] propose a case-based transformation approach. Two-dimension reduction methods are presented, principal component analysis (PCA) and feature selection. Mandel *et al.* [51] present a method to define which policies to use to present information to solve complex reinforcement learning problems. Wang *et al.* [55] describe how reinforcement learning can be used to interactively create understanding and knowledge, while Peña *et al.* [54] introduce multi-role interactions to model MASs.

Seven papers are identified on Level 3. Consoli *et al.* [52] discuss a cognitive model to agent coordination and cooperation with the help of Belief Desire Intent and Observe Orient Decide and Act while Rey *et al.* [57] describe different cooperation models between humans and compositional systems. Gómez-Cruz *et al.* [53] suggest simulations to evaluate interactions between individuals and/or organisations. Two studies focus on narrowing the gap between human and machine actors [56, 59]. Riekstin *et al.* [58] discuss requirements for policy refinement and give guidance for policy abstraction levels while Wiesner *et al.* [25] list challenges in constructing cyber-physical systems.

4.1.6 RQ 1.6: Looking at the seven identified studies regarding validating the matching of intents expressed by human actors and machine actors, we classify three studies on Level 1. Beigi *et al.* [37] suggest validation of the intents by transporting goals into policy configurations with the help of PCA and feature selection for dimension reduction. Mandel *et al.* [51] present a method to define which policies to use to present information to solve complex reinforcement learning problems. The comparing and validation of the policies are done offline with the help of the importance sampling method. Lan and Baraniuk [60] focus on defining which learning action a person should undertake to find relevant solutions.

Only one study is identified in Level 2 and three studies on Level 3. On Level 2, Wang *et al.* [55] describe how reinforcement learning can be used to interactively create understanding and knowledge. Studies on Level 3 focus on how agent-based

Table 9 Comments on papers not passing criterion level 1

Paper	Contributes to RQ	Comments
[38]	1.3, 1.4	Theory: The paper describes what is needed by an adaptive policy framework. Some findings might be of use for Intent-Driven Systems.
[18]	1.1	Theory: Describes the theory for combining Monte Carlo simulation with Multi-Actor Multi-Criteria Analysis.
[16]	1.1, 1.3	Theory combined with experiment: Constructing a tool 'MeTAGeM' that supports Model-Driven Development of model transformations.
[39]	1.3	Theory: Provides a theory of what is needed to be able to apply Digital Policy Management. This might be useful from an Intent-Driven System's point of view.
[17]	1.1	Theory combined with experiment: Using MAS to combine different context frames. The case-based approach is used to find new outcomes. The agent structure is described. The different adoptions points when context frames are changed are highlighted.
[52]	1.5	Theory: Introduce a cognitive model to agent coordination and cooperation with the help of Belief Desire Intent and Observe Orient Decide and Act.
[22]	1.1	Theory combined with experiment: Uses cognitive input to offload humans depending on their state. Using a neural network and statistical analysis to determine the mental state of a human. No indications on how the context frames where deployed. This has some significance for a generic Intent-Driven System.
[53]	1.5, 1.6	Theory: The paper describes how agent-based simulations can be used to evaluate interactions between individuals and/or organisations. There are some findings that might be of use for Intent-Driven Systems.
[23]	1.1	Theory combined with experiment: Multi-Criteria Decision Analysis based on an agent solution. The desire from one of the actors has to be correlated with the constraints to fulfil the desires of the second actor. There are no proposals on how to create the needed context frames and how to align the context frames.
[19]	1.1	Theory: MAS is used for the integration of DSSs. The theory might be useful since integration of existing DSSs is part of a realistic Intent-Driven System implementation. Different ontology constructs are discussed in the paper.
[24]	1.1, 1.2	Theory: Describes a process for policy formulation and policy options.
[42]	1.3	Theory: Policy-based management based on OWL-S. Describing the input, output, preconditions and effects on a service and the resources used by the service. Using semantic query-based network services to collect network status information.
[56]	1.5	Theory: How to narrow the gap between human (linguistic) fuzzy model and evolving fuzzy models. This is a position paper but the ideas might be useful.
[28]	1.1	Theory combined with experiment: The theory might be useful since it combines Natural Language Processing with knowledge and mental models. The focus of the paper is a component called 'semantic de-biased associations model,' which are using a semantic triple to combine concepts (expressed in Natural Language) with associations (a weighted meaning) and history (cases). The experiment is done with a proprietary tool.
[41]	1.3	Theory combined with experiment: Using Dynamic Bayesian Network together with risk estimation to present awareness to the operator in a way that makes it easier for the operator to take the right decisions in a stressful situation. It is possible to simulate the effect of an action taken by the operator but the action will not be enforced from the system.
[54]	1.5	Theory combined with experiment: Uses Unified Modelling Language to model MASs and add a first-class modelling element called multi-role interaction (mRI) in order to represent interactions abstractly. There are two static organisation view models: Role model and Ontology model (not shown in the paper). Together with behaviour organisation view and traceability view. This is built in to a proprietary tool but the ideas are useful.
[43]	1.3	Theory: The paper reason about different ways (and schools) to represent knowledge. This fits with the problem of defining a context frame.
[32]	1.1	Theory combined with experiment: Extends Market Driven Agents with the capabilities to negotiate when the environment becomes open and dynamic.
[57]	1.5, 1.6	Theory: The paper describes different cooperation models between humans and compositional systems.
[58]	1.5, 1.6	Theory: The paper describes requirements for policy refinement and gives guidance for policy abstraction levels. There are some findings that might be of use for Intent-Driven Systems.
[45]	1.3, 1.4	Theory: The paper describes the needed improvements for service negotiation. Some findings might be of use for Intent-Driven Systems.
[44]	1.3, 1.4	Theory combined with experiment: Using simulation to validate the effect of new parameter settings with the help of information from the real environment. A specific real-time simulation protocol (ArenaRT) is used.
[46]	1.3, 1.4	Theory: The paper describes what is needed to make semantics enabled web services useful in practice. There are some findings that might be of use for Intent-Driven Systems.
[47]	1.3	Theory combined with experiment: Using a holonic MAS to optimise the allocation of resources. This gives an insight into how an agent can play different roles depending on its interactions.
[59]	1.5	Theory: Describes a way to break down the information at different levels to make it more understandable and manageable. This is done in order to make sure that certain resources can provide information in order to meet a specific goal(s). This theory could be useful input to Intent-Driven Systems.
[33]	1.1, 1.3	Theory combined with experiment: Describes how agents can change according to the surroundings as well as to changes in goals. The solution is based on the deliberative coherence theory. How the needed information for a context frame is entered is not in the scope of this papers.
[48]	1.3, 1.4	Theory: The paper describes what is needed to achieve semantical annotation of web services. There are some findings that might be of use for Intent-Driven Systems.

Paper	Contributes to RQ	Comments
[49]	1.3	Theory: Focus on how agents can find the required skill from other agents when needed. A protocol for this issue is presented.
[55]	1.5, 1.6	Theory combined with experiment: The paper describes how reinforcement learning can be used to interactively create understanding and knowledge. The human actor is modelled as a Partly Observed Markov Decision Process.
[25]	1.1, 1.3, 1.5	Theory: Challenges for Requirement Engineering in constructing CPSs. Definitions of terms and suggestions for using Natural Language Processing as a tool for the Requirement Engineering. The information is based on a Systematic Literature Review. This paper highlights the problems that have to be solved in an Intent-Driven System.

Table 10 Mapping of papers related to governance frameworks or methods to interchange semantics and ontologies between actors

Topic	Discussed	Investigated
governance framework	[25, 37, 42]	—
interchange of semantics and ontologies	[15, 17, 27, 38]	[16, 42]
	[19, 30, 41]	
	[36, 43, 54]	
	[25]	

simulations can be used to evaluate interactions between individuals and/or organisation [53], different cooperation models between humans and compositional systems [57], and requirements for policy refinement and gives guidance for policy abstraction levels [58].

4.2 RQ 2

The analysis regarding RQ2 is divided into the following aspects needed to enable realisations of intent-driven systems: (i) Semantics, (ii) Interchange of semantics, (iii) Governance, (iv) Actor interaction and (v) Commonalities (Theories supporting more than one research question.). We use all the papers in Table 5 to evaluate if the aspects are present in the literature. The fifth aspect is used to understand if a theory supports more than one research question.

Most papers take a common understanding between different actors for granted. These papers do not consider the fact that the same data could have a different meaning to different actors due to the actors' individual context frames. Only a few of the papers indicate the lack of semantics and ontologies but select a proprietary model to be able to experiment. It is not evident that the different methods/techniques can be used together due to the tight coupling between the realisation and the information in each solution. Neither do we find any evidence of the governance aspects in the presented methods/techniques (Table 10).

Below, we discuss each of these aspects in further detail.

4.2.1 Semantics: Business intents and their life cycles are developed and maintained through interactions. With the help of the various methods found in the papers (as listed in Table 5), these interactions are performed as collaborations between different actors. The outcome of an interaction between human actors results in conclusions stated in natural language. From a software engineering perspective, the conclusions can be made executable in the form of policies and rules, but this would require natural language processing, suggested in [25], and a formal way of expressing the policies and rules, for example using Semantics of Business Vocabulary and Rules [61]. Since Semantics of Business Vocabulary and Rules is business agnostic, semantics and ontologies are needed to give meaning to the policies and rules:

> 'We can summarise that currently, there is no approach that deals with the distributed nature and the existing information asymmetry of the enterprise management domain appropriately and allows for some support by means of application systems.' [27].

> 'Several factors hinder communication, among which are the closed nature of the individual projects and terminological differences.' [62].

4.2.2 Interchange of semantics: Most papers take a common understanding between different actors for granted. Only a few of them indicate the lack of semantics and ontologies but select a proprietary model to be able to experiment. Methods found in the papers (as listed in Table 10) provide possibilities for the semantic interchange of information, or the abilities to match actors' business intents. However, the papers do not consider the fact that the same data could have a different meaning to different actors due to the actors' individual context frames.

> 'Interoperability of the CPS (Cyber-Physical Systems, our note.) elements has to be guaranteed by specific requirements. Dynamically changing and emergent behaviour must be included in the CPS specification. Natural language could be used as an informal requirements specification for exchange between the system user and stakeholders from various disciplines, but is often unclear and ambiguous. Furthermore, it can barely be handled automatically.' [25].

4.2.3 Governance: Compositional systems need governance since new or modified business intents introduce changes in the policies and rules. Methods that could be considered in the validating part of a governance framework are only discussed in some of the papers (as listed in Table 10). We find no evidence of the governance aspects of the presented methods/techniques.

4.2.4 Actor interaction: Different combinations of interactions between human actors, machine actors, and the environment to fulfil a business intent could be found. The presence of the human actors, machine actors, and the environment is either existing in the real world, outside a solution, or are embedded in the solution in the form of, for example survey data, specific models of humans or the simulated environment for a specific instance of a problem. In the literature, on criterion level 1 only one real-world actor is supported to interact with a solution. Combinations with more than one real-world actor exist in the literature [17, 19, 23], but it is not evident that the combinations presented in the literature can be used in other domains due to the tight coupling between the realisation and the information in each solution.

4.2.5 Commonalities: Some theories found in the literature are common to more than one of the research questions (RQ1.1–RQ1.6). This indicated a possibility to enable realisations of intent-driven systems. MASs are used in papers answering RQ1.1 and RQ1.3. Multi-criteria decision analysis supports this for RQ1.1 and policy-based systems for RQ1.3. In papers supporting RQ1.5 natural language processing is suggested as a bridge between RQ1.1 and RQ1.3, but in practice, this is hard to achieve due to different abstraction levels [25]. PCA is used as a common theory for RQ1.6. No common theories for RQ1.2 or RQ1.4 are found. It seems difficult to combine the different interaction patterns to enable realisations of intent-driven systems due to the literature's limited evidence of governance frameworks combined with the lack of methods to interchange semantics and ontologies between actors (Table 10).

> ‘there is a huge semantic gap between the high-level specifications collected in PIT (Platform Independent Transformation, our note.) models and the particularities of a given transformation language collected in a PST (Platform Specific Transformation, our note.) model.’ [16].

> ‘to the best of our knowledge, there is no agent-based approach proposed for the enterprise management domain so far. The interaction of agents is based on communication. Therefore, appropriate semantics and ontologies are required to allow for modelling collaborations between different enterprises (cf., for example, Vaishnavi and Kuechler 2005). However, it seems that a unified semantics and ontology is missing, but the enterprise ontology (cf. Uschold *et al.* 1997) is an appropriate starting point.’ [27].

> ‘We thus emphasise the point that as autonomic management is essentially human governance resulting in the constraint of adaptive behaviour using policies, we must address the semantics of both adaptive networks and adaptive application software in relating such policies to the expected human experience. This approach, however, leaves many open questions relating to the limits of semantic-based reasoning in the context of adaptive, networked systems.’ [42].

4.3 Summary

Albeit there exist methods and techniques (listed in Table 5), addressing each of RQ1's sub-questions, the synthesis shows no evidence of how these methods/techniques can interact with the aspects needed to enabling realisations of intent-driven systems. The existence of methods/techniques that can be used to express business intents and transfer or translate business intents between different actors’ domains are not evidently available in the existing literature. No evidence of the governance aspects needed to enable realisations of intent-driven systems could be found in the literature. It is not evident that the actor interaction combinations presented in the literature can be used in other domains due to the tight coupling between the realisation and the information in each solution.

We find few studies on large-scale open systems and notice low industry involvement in the existing literature. RQ1.1 and RQ1.6 are the only research questions on criterion level 1 having industry involvement.

5 Discussion

Many valuable contributions to intent-driven systems are presented, but there is a lack of evidence for enabling realisations of intent-driven systems in the existing literature. Only a minority of the studies are done on large-scale open systems, or with industry involvement, which might be one explanation of the lack of evidence for enabling realisations of intent-driven systems. Another explanation might be the core idea of intent-driven systems; we are investigating the existence of methods/techniques and aspects which could serve as a generic foundation of systems that could change the behaviour of the system itself, based on stakeholder intents. The majority of the papers found during the study use an instance centric view of the problem they solve, which introduces tight coupling between the realisation and the information in each method/technique.

The construction of a compositional system requires methods to achieve a holistic collective benefit through the individual systems’ participation and cooperation when each system adopts to a solution that maximises its own self-interest [5]. For example, when constructing a compositional system, it is necessary to understand the information in a system‘s context frames as well as having temporal separation [63] to coordinate and cooperate in uncertain environments [52]. The context frame is a key concept in achieving context-aware business architectures. It is vital to understand which context applies in a specific situation and how one should react upon this. In a compositional system, multi-context capabilities are needed [64]. Since an actor's context frame might have to act in several roles. Most contributions in this study are found in the area of expressing and validating human actor‘s intents (RQ1.1 and RQ1.2, to some extent RQ1.5 and RQ1.6, were covered). The focus is one context frame (with real-world actors) only. This may be a sufficient starting point, but the transformation between different context frames in a later stage in not evidently described or addressed in the literature. Wiesner *et al.* [25] propose Natural Language Processing as an alternative to producing formal descriptions of the conclusions from the text-based results, but no solutions are given.

The information management for an enterprise being part of a compositional system becomes a critical aspect [65]. It is not evident that the validating methods/techniques of the transformations presented in the literature can be used in other context frames due to the tight coupling between the realisation and the information in each method/technique (RQ1.2, RQ1.4, and RQ1.6). The contributions covering reusable capabilities and characteristics of software components do not take different context frames into consideration (RQ1.3 and RQ1.5). How to re-use the methods/techniques in different domains is not evidently available in the literature. For example, when changing between domains, new ontologies might be needed. Frameworks supporting ontology negotiation exists, for example the FIPA Communicative Act Library Specification [66] used in JADE (JADE is proposed in [33]), but the translation capabilities between different context frames are not part of the found frameworks.

There is a need for governance since new business intents or a change of existing business intents introduces changes in the configuration of a compositional system. This problem is brought up by Wiesner *et al.* [25], but no solutions are given. In each part of a solution, there exist problems of changing configurations in a way that are effective and efficient [67]. Before the changes are introduced, the effectiveness and efficiency of the business intents should be evaluated, for example with capability levels [68]. Each actor's level of automation of decision and action selection has to be governed. The governance aspects of the presented methods/ techniques are not evidently available in the literature.

5.1 Validity threats

In this section, we discuss validity threats, according to Robson [69].

5.1.1 Author bias: An extensive history as an industry practitioner may have influenced the aims of the study with a stronger bias towards ready solutions. A rigorous review methodology with stringent research questions helps to avoid the risk that articles are dismissed without due consideration.

5.1.2 Finding the relevant papers for the study: To avoid missing important search terms in the search string, the initial keywords were obtained from the research questions and through brainstorming with domain experts from academia and the industry. During the pilot study, the papers selected as primary studies for full-text reading were used to find new keywords for the search string. The authors’ keywords were extracted from the selected papers. We selected the keywords to be part of the search string based on our understanding of intent-driven systems.

5.1.3 Multiple subject areas: Since we are searching in multiple subject areas, some of the words and concepts have a different meaning in the context of the different subject areas. In order to better understand the meaning, we analysed one subject area at the time, and read the relevant parts of the papers several times, in order to incrementally revise the authors’ understanding of the different subject areas.

5.1.4 Selection of information sources: Since the selection of information sources should cover a wide range of disciplines with its base in computer science, we used Scopus, ISI/web of science, ACM digital library, and IEEE Xplore as information sources. To mitigate the risk of missing vital information sources, we were recommended by a colleague to compare our search results with Inspec. We assumed the coverage to be fulfilled since ACM digital library and IEEE Xplore are indexed by Inspec. To validate our assumption, we performed a search in Inspec after the data extraction process. The reference management system showed that only duplicates were found.

5.1.5 Inclusion/exclusion criteria: The research questions cover a broad topic. Thus, we used for inclusion and exclusions criteria that limit the number of papers to read. During the pilot study, the inclusion and exclusion criteria were evaluated with a domain expert. Later, discussions between the authors were used to judge if a paper should be excluded with respect to EC1, if we were in doubt. If no agreement could be made between the authors, the domain expert was used to judge if the paper should be excluded with respect to EC1.

5.1.6 Quality assessment criteria: We saw a need to use an additional quality assessment to assess the level of contribution from each article towards intent-driven systems. During the pilot study, the quality assessment criteria were evaluated with a domain expert. Later, discussions between the authors were used to judge how a paper should be ranked if we were in doubt. If no agreement could be made between the authors, the domain expert was used to decide the level of contribution.

5.1.7 Rigour and relevance of the selected papers: The goal of this study is primarily to extract *ideas* that may be of use for intent-driven systems. Therefore, we choose not to perform a thorough analysis of rigour as per, e.g. Ivarsson and Gorschek [70]. Instead, we focus on relevance, using the quality assessment criteria listed in Section 3.2.3. This classifies the papers into three levels, with level 1 containing the most relevant ideas for constructing an intent-driven system.

6 Conclusion

Currently, there is a lack of overview of available methods/techniques available for supporting business intents, and in particular, methods/techniques that cover the life cycle perspective of business intents. To address this, we conducted a systematic literature review on methods and techniques that support intent-driven systems, and the aspects needed to enabling realisations of intent-driven systems.

RQ1 is aimed at finding evidence in the literature for the support of intent-driven systems, divided into sub-questions RQ1.1–RQ1.6, each covering one vital aspect of intent-driven systems. RQ2 aims to find evidence in the literature of how the result of RQ1's sub-questions could be used to enable the realisation of intention driven systems.

The results indicate that while there are methods and techniques addressing each of RQ1's sub-questions, listed in Table 5, the synthesis shows no evidence of how these methods/techniques can interact with the aspects needed to enabling realisations of intent-driven systems. For example, the governance of intent-driven systems as well as possibilities for the semantic interchange of information is not evidently available in the literature.

The existences of methods/techniques which can be used as building blocks to construct intent-driven systems exist in the literature. How these methods/techniques can interact with the aspects needed to enabling realisations of intent-driven systems is not evident in the existing literature.

This indicates a need for further research regarding the semantic interchange of information, actor interaction in intent-driven systems, and the governance of intent-driven systems.

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