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EXAMINING APPROACHES AND ADDRESSING THE NESTING CHALLENGE IN DECISION SUPPORT SYSTEMS

Nikolaj Krebs Pedersen

Jonas Valbjørn Andersen

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Research paper

Pedersen, Nikolaj Krebs, IT University of Copenhagen, Copenhagen, Denmark, nped@itu.dk

Andersen, Jonas Valbjørn, IT University of Copenhagen, Copenhagen, Denmark, jova@itu.dk

Abstract

The decision support systems (DSS) research literature within Information Systems (IS) is riddled with various overlapping definitions and approaches. Through an extensive literature review, this paper identifies key definitions, dimensions, and trends in the DSS literature and provides a unified classification. Based on the identified constructs, we identify a nesting challenge in DSS defined as the oversaturation of DSS approaches that occurs by continuously creating new approaches to cover specific use cases. We also argue that not all DSS approaches are comparable, as they address different aspects of decision support systems, with some defining application areas, while others focus on the technique or technology used. Through a discussion of the literature and the nesting classification, the paper draws on conceptual dimensions from business analytics (BA) research to define DSS approaches as domain-specific or technique-specific. From this point of departure, this paper calls for further research on integrating BA and DSS to enrich the application of DSS approaches in design and implementation. This literature review contributes to IS literature by showcasing a new perspective to create coherence within the DSS discipline.

Keywords: Decision Support Systems, Machine Learning, Business Analytics, Literature Review

1 Introduction

As data analytics, machine learning, and artificial intelligence are increasingly applied to information systems involving varying degrees of autonomous decision-making (Benbya et al., 2020a; 2020b; Faraj et al., 2018; Marabelli & Newell, 2017), Handling these changes within computer-augmented and automated decision-making becomes increasingly pivotal in ensuring appropriate DSS design and implementation (Phillips-Wren et al., 2021). Early developments of DSS research sought to define the integration of computer-based decision-making processes, emphasising the significance of analytical models that leverage data to inform decision-makers (Pieptea & Anderson, 1987; Eierman et al., 1995). The earlier DSS literature focused on knowledge transfer from operations to management decision-making (Fazlolahi et al., 1997), significantly affecting strategic performance (Haghighi et al., 2013). More recent DSS literature focuses on leveraging artificial intelligence in intelligent decision support systems (Ivanov & Webster, 2024; Dohale, 2024; Ha & Kim, 2023).

However, through the vast body of DSS literature, many approaches have been presented to handle computer-based decision-making. With literature from the early 1970s, many authors have given ways to develop DSS within specific fields. That is specified by its domain implementation, targeted towards one person or group (Javadi & Gebauer, 2019) or the utilisation of one type of technology or technique (Duan et al., 2019). Thus, the question of navigating these different DSS approaches and how they interact is raised, as the terminology could be ambiguous.

The purpose of this paper is to examine the different approaches of DSS, highlight challenges, and discuss ways to navigate DSS spanning domains and techniques, thus exploring how DSS approaches

are interconnected and, in turn, finding potential opportunities for combining them. It does this by investigating the research question: "What is the current state of Decision Support Systems approaches across different domains and techniques, and how can *future research address ambiguity and overlap between the approaches?".*

To explore this research question, this paper first presents a definition and background of DSS before presenting a systematic literature review, utilising the Hermeneutic literature review framework (Boell & Cecez-Kecmanovic, 2014), focusing on DSS literature within Information Systems Research. Through searching and sorting, this paper reviewed 174 articles, resulting in the selection of 51 articles, providing an overview of six DSS approaches: *Personal Decision Support Systems (PDSS), Group Support Systems (GSS), Negotiation Support Systems (NSS), Intelligent Decision Support Systems (IDSS), Business Intelligence (BI), and Knowledge Management-Based Decision Support Systems (KMDSS).* Analysing the presented literature, articles were classified into each approach, highlighting the overlap between many approaches. Further discussion of these findings resulted in the definition of a potential nesting challenge within the DSS discipline and a proposed way of navigating the several approaches and their overlap.

2 Background

Decision Support Systems are computer-based systems that aim to aid decision-makers in solving unstructured decision-making problems by combining statistical models and data analytic techniques (Sprague, 1980; Hackathorn & Keen, 1981; Mann & Watson, 1984). As one of the central pillars of Information Systems (IS) (Sprague, 1980), DSS has seen significant development over time, especially in the scope of its applications, and has expanded into numerous different approaches (Arnott & Pervan, 2014). These approaches now cover vastly different domains of DSS application.

DSS was developed in the early 1970s and 1980s, aiming to define the interaction of computer systems to support decision-making through data analysis (Sprague, 1980). Starting as a way to manage computers and the changes they brought to information management, DSS was created to handle these changes by reassessing how resources were allocated to support decision-making (Gorry & Morton, 1971). Continuing its research through the 80s, DSS had found a secure footing as part of the management information research. Solidifying its definition as knowledge-based systems compiling information from structured and unstructured data into models to support decision-making and problem-solving, being that of simple query-based systems or complex human decision-making processes (Belciug & Gorunescu, 2019).

Following a normative approach to decision-making, combining models and analytics with data, decision-makers can gain flexible and adaptable insights in changing environments (Pieptea & Anderson, 1987; Eierman et al., 1995). Targeted toward handling unspecified problems of management and domain experts, DSS provides structured computer-based systems that, through the incorporation of databases, models, and computer interfaces, allow for the exploration of unstructured problems (Todd & Benbasat, 1987; Finlay & Forghani, 1998). Through these systems, DSS significantly influences implementation strategy performance by representing knowledge to decision-makers in a structured manner (Eierman et al., 1995; Fazlollahi et al., 1997; Haghighi et al., 2013).

Through the literature review presented in this paper, we show how the DSS field has witnessed the development of numerous diverse approaches. These approaches share similar domains and orientations (Fazlollahi et al., 1997). Drawing from the definition of DSS by Arnott and Pervan (2014), DSS are categorised into six distinct approaches: *Personal Decision Support Systems, Business Intelligence, Group Support Systems, Negotiation Support Systems, Intelligent Decision Support Systems,* and *Knowledge Management-Based Decision Support Systems.* This paper will leverage this categorisation as a foundation for identifying and discussing the nesting challenge in DSS by providing a unified classification.

3 Methods and Research Design

This paper conducted a systematic literature review to summarise the literature within the existing body of DSS research. Following the Hermeneutic literature review framework described by Boell & Cecez-Kecmanovic (2014). In this paper, the authors draw from the hermeneutics philosophy, interpreting the process of engaging with literature as iterative and ever-expanding in deepening the given understanding of literature (Boell & Cecez-Kecmanovic, 2014). They describe two hermeneutic circles: a wider circle - *analysis and interpretation*, and an inner circle - *search and acquisition*. Together, these represent the process of seeking information and gaining insights from literature (Boell & Cecez-Kecmanovic, 2014). The inner circle consists of 7 activities: *Searching, Sorting, Selecting, Acquiring, Reading, Identifying,* and *Refining.* The wider circle consists of 6 activities: *Reading, Mapping and Classifying, Critical assessment, Argument development, Research Problem / Questions,* and *Searching*. These activities aim to seek information about a given problem and identify more relevant sources of information (Boell & Cecez-Kecmanovic, 2014).

The hermeneutic literature review framework allows for an iterative approach to reading, assessing, and analysing the literature on DSS. This literature review is conducted by applying the activities of the inner and wider hermeneutic circle.

3.1 Searching, Sorting, and Selecting

The literature review was initiated by searching relevant keywords related to the initial research questions. The first iteration of research questions derived from questions that arose during the reading and assessment of the paper "*A critical analysis of decision support systems research revisited: the rise of design science*" by Arnott & Pervan (2014). This paper presents several DSS approaches: *Personal Decision Support Systems, Group Support Systems, Negotiation Support Systems, Intelligent Decision Support Systems*, *Business Intelligence,* and *Knowledge Management-based Decision Support Systems*. Through these defined approaches, the authors wished to analyse the current state of DSS research critically, classifying and discussing literature within the eight DSS approaches. The predominant question that arose from this article was if and how these approaches overlap. This led to the first iteration of searching, sorting and selecting articles. This process was done manually by looking at the reference list of the articles and using the Litmaps application[1]. This application allows for the discovery of related research articles through algorithmic means.

The literature search was instantiated through citation analysis (Greenhaigh & Peacock, 2005) of the article by Arnott & Pervan (2014). This iteration collected articles based on first going backwards in citations, allowing for the collection of prior articles. This was followed by going forward in citations and collecting articles that had cited the before-mentioned article. The citation analysis led to the initial understanding of the DSS literature, which supported the production of the following search terms that were applied during the literature review:

- "Decision Support Systems"
- "Decision Support Systems" AND "Personal Decision Support Systems"
- "Decision Support Systems" AND "Group Support Systems"
- "Decision Support Systems" AND "Negotiation Support Systems"
- "Decision Support Systems" AND "Intelligent Decision Support Systems"

[1] See https://litmaps.com

- "Decision Support Systems" AND "Business Intelligence"
- "Decision Support Systems" AND "Knowledge Management-based Decision Support Systems"
- "Personal Decision Support Systems" OR "Group Support Systems" OR "Negotiation Support Systems" OR "Intelligent Decision Support Systems" OR "Business Intelligence" OR "Knowledge Management-based Decision Support Systems"

These search terms were then used to study how the different DSS approaches were utilised within the literature. To ensure that the literature review was grounded in the Information Systems literature, the criteria of only including articles from the *Senior Scholars' List of Premier Journals* by the Association for Information Systems and its affiliated conferences (Association for Information Systems (AIS), n.d.).

Using these criteria, we searched the *Scopus database*, *Google Scholar,* and *the Elsevier Research Products API*. Selecting articles based on titles, keywords, and abstracts. 174 articles were initially selected.

3.2 Acquiring, Reading, Identifying, and Refining

Following the selection of the 174 articles, each paper was acquired and read extensively. Thus, essential terms, citations, and additional DSS approaches were identified. Additionally, this process also allowed for excluding articles that were deemed not to be relevant. Several criteria determined this exclusion. The literature review was conducted to identify different DSS approaches. Thus, articles that did not discuss the development of DSS were excluded. This was predominantly case studies as DSS was utilised as a theoretical lens rather than discussing DSS as a whole. Based on these criteria, 124 articles were excluded, resulting in 51 articles from 17 different publications being included in the literature review. The number of research articles and the sources from which they hail are presented in Figure 1.

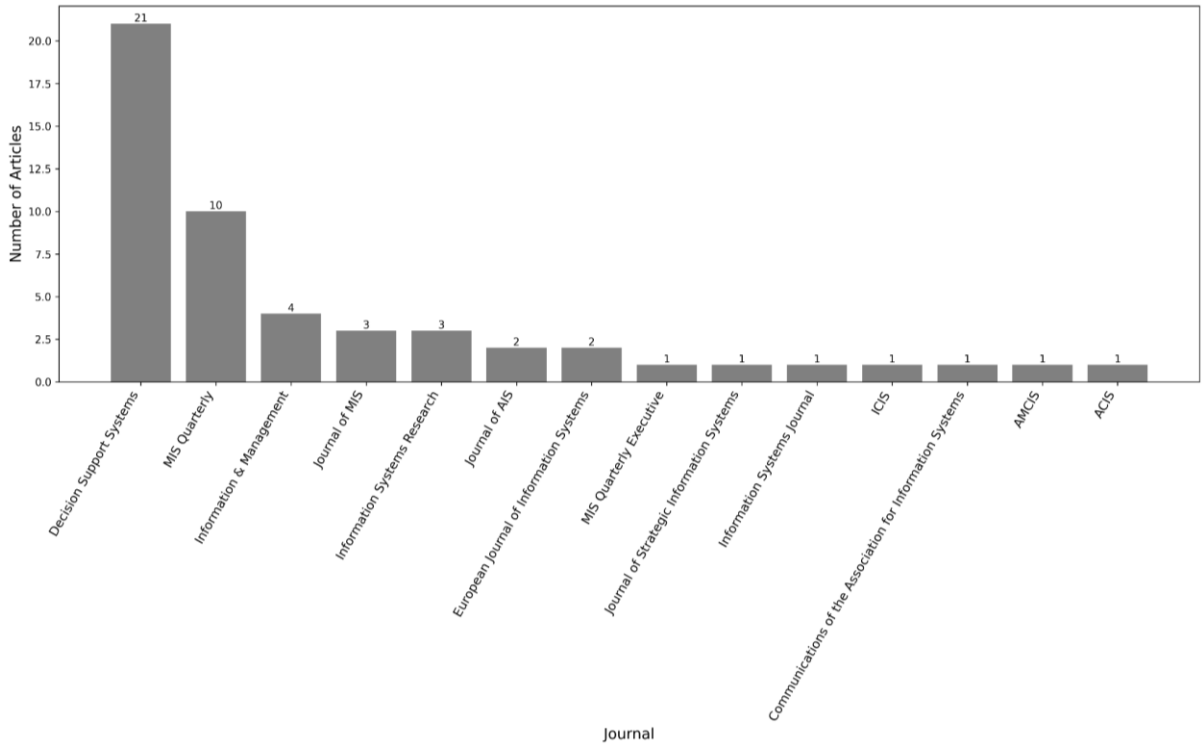

Figure 1. Distribution of DSS Research Articles Across IS Journals

4 Literature Review

Following the hermeneutic literature review framework, this paper analyses the selected literature by mapping and classifying references based on the six approaches defined by Arnott and Pervan (2014) presented in section 2. Following this method, we identify and critically assess key definitions and trends within DSS literature.

4.1 Mapping and Classifying *Decision Support Systems Approaches*

We initially classified the DSS literature based on the approaches discussed in the given reference to map and classify the collected literature. This classification was defined by the different DSS approaches (PDSS, GSS, NSS, IDSS, and BI). The classification of DSS was also included to investigate literature that covered DSS as a whole but did not specify its research on a specific approach. Table 1 shows all 51 included references classified by their associated classification. Some papers can occur within multiple categories, illustrating that that reference covered more than one DSS class. Additionally, definitions for each classification are included, and this definition is used to classify which article covered which classification.

Classification	Definition	References
DSS	DSS is aimed at aiding decision-makers in solving unstructured decision-making problems by combining statistical models and data analytic techniques (Sprague, 1980; Hackathorn & Keen, 1981; Mann & Watson, 1984).	Sprague (1980), Pieptea & Anderson (1987), Todd & Benbasat (1987), Walls et al. (1992), Eom et al. (1993), Gottinger & Weimann (1995), Demirkan & Delen (2003), Arnott & Pervan (2005), Arnott & Pervan (2008), Watson (2011), Arnott & Pervan (2012), Haghighi et al. (2013), Arnott & Pervan (2014), Fazlollahi & Vahidov (2015), Maldonado et al. (2019), Arnott & Gao, (2019), France et al. (2021), Muchenje & Seppänen, (2023), Herath Pathirannehelage et al. (2024)
PDSS	PDSS are DSS that are developed to facilitate one or a small group of decision-makers (Arnott & Pervan, 2007)	Hackathorn & Keen (1981). Henderson & Schilling (1984), Finlay & Forghani (1998), Arnott & Pervan (2005), Arnott & Pervan (2008), Arnott & Pervan (2012), Arnott & Pervan (2014), Wang et al. (2022)
GSS	GSS facilitates decision-making between more prominent groups, sharing data and communication through implemented electronic meeting systems (Rathwell & Burns, 1985; Eom et al., 1993; Dennis et al., 1997).	Locander et al. (1979), Rathwell & Burns (1985), Walls et al. (1992), Eierman et al. (1995), Fazlollahi et al. (1997), Finlay & Forghani (1998), Santhanam et al. (2000), Arnott & Pervan (2005), Arnott & Pervan (2008), Arnott & Pervan (2012), Arnott & Pervan (2014), Adla & Benmessaoud (2019), Javadi & Gebauer (2019), Wang et al. (2022)
NSS	NSS supports groups with negotiating problems and processes through computer-based techniques (Arnott & Pervan, 2005).	Arnott & Pervan (2005), Arnott & Pervan (2008), Arnott & Pervan (2012), Arnott & Pervan (2014), Yu et al., (2021)
IDSS	IDSS are systems that apply artificial intelligence techniques to DSS (Remus & Kottemann, 1986; Arnott & Pervan, 2008).	Remus & Kottemann (1986), Pieptea & Anderson (1987), Dennis et al. (1997), Fazlollahi et al. (1997), Finlay & Forghani (1998), Arnott & Pervan (2005), Arnott & Pervan (2008), Arnott & Pervan (2012), Arnott & Pervan (2014), Abbasi et al. (2016), Döppner et al., (2016), Duan et al. (2019), Shojaeizadeh et al. (2019), Konovalenko et al. (2021), Wang et al. (2022), Rabl et al. (2023), Herath Pathirannehelage et al. (2024)

BI	BI are systems that utilise data analytics to support decision-makers at all levels of an organisation (Arnott & Pervan, 2008).	Hackathorn & Keen (1981). Huber (1981), Hogue & Watson (1983), Meador et al. (1984), Hogue & Watson (1985), Fitzgerald (1992), Dennis et al. (1997), Santhanam et al. (2000), Copper et al. (2000) Arnott & Pervan (2005), Arnott & Pervan (2008), Watson (2011), Arnott & Pervan (2012), Liebowitz (2013), Arnott & Pervan (2014), Davenport (2014), Lycett (2013), Kowalczyk & Buxmann (2015), Phillips-Wren et al. (2017), López-Robles et al. (2019), Ain et al., (2019), Philips-Wren et al. (2021), Jeyaraj (2022)
KMDSS	KMDSS are systems that support managerial decision-making and enhance knowledge application and storage, either in the context of a singular decision-maker or organisational (Gintzberg, 1978; Arnott & Pervan, 2014)	Ginzberg (1978), Hogue & Watson (1983), Mann & Watson (1984), Meador et al. (1984), Walls et al. (1992), Fazlollahi et al. (1997), Arnott & Pervan (2005), Arnott & Pervan (2008), Arnott & Pervan (2012), Arnott & Pervan (2014), Duan et al. (2019), Wang et al. (2022)

Table 1. Decision Support Systems Approaches: Classifications and Key References

Table 1 illustrates that NSS is the least referenced DSS approach, with BI, DSS, and IDSS being the most prominent approaches within the collected research. When investigating the references covering the NSS approach, they are shown to be predominantly referenced by Arnott and Pervan (2021). This indicates that this approach might not be used predominantly throughout the DSS literature. Many references cover the research field of DSS in general rather than focusing on any specific approach. BI also contains many references, which is also likely, as its definition covers several DSS approaches into one. Table 1 shows a significant overlap between references regarding the approaches covered, with eight references occurring three or more times.

4.2 Mapping and Classifying *Business Analytics in Decision Support Systems*

A predominant concept identified during the literature review was Business Analytics (BA), which was mentioned as a rising concept within DSS literature (Pathirannehelagea et al., 2024). In addition, BA has also been often intertwined with BI through the acronym BI&A (Business Intelligence and Analytics) (Phillips-Wren et al., 2021). To identify the prevalence of BA in the DSS literature, this paper has classified the references that mention BA in Table 2. Through this classification, it is illustrated that several of the references covering BI also overlap with BA-classified articles (Meador et al., 1984; Arnott & Pervan, 2008; Watson, 2011; Liebowitz, 2013; Lycett, 2013; Davenport, 2014; Phillips-Wren et al., 2017). Highlighting the association between the two: BI&A. In addition, the references classified in Table 2. also show overlap with other DSS approaches classified in Table 1 (Sprague, 1980; Arnott & Pervan, 2008; Watson, 2011; Locander et al., 1979; Döppner et al., 2016), further illustrating the predominance of BA in DSS literature.

Classification	Definition	References
BA	BA is focused on identifying and solving decision-making problems based on data that occur within business environments (Holsapple et al., 2014)	Locander et al. (1979), Sprague (1980), Meador et al. (1984), Arnott & Pervan (2008), Arnott & Pervan (2012), Watson (2011), Lycett (2013), Liebowitz (2013), Demirkan & Delen (2013), Arnott & Pervan (2014), Davenport (2014), Goes (2014), Holsapple et al. (2014), Fazlollahi & Vahidov (2015), Kowalczyk & Buxmann (2015), Phillips-Wren et al. (2015), Döppner et al., (2016), Abassi et

		al. (2016), Phillips-Wren et al. (2017), Müller et al. (2018), López-Robles et al. (2019), Beckwith (2020), Philips-Wren et al. (2021), Muchenje & Seppänen, (2023), Herath Pathirannehelage et al. (2024)

Table 2. Business Analytics classification and references

4.3 Critical Assessment

In classifying the reviewed literature, one aspect of the DSS body of literature was that an approach should have been mentioned or highlighted in the articles. Thus, the classifications were determined based on the context of how DSS was focused or mentioned in the article. This led to further questions regarding the importance of DSS approaches. This is again highly reflected in the classification of NSS (Table 1.) as it was Arnott & Pervan who were shown to be the only users of this approach within the context of the 51 selected papers. Likewise, the articles classified as BI were assessed based on the broad definition by Arnott and Pervan (2014) as encapsulating both executive information systems (EIS) and data warehousing. Thus, articles focusing solely on data warehousing or executive information systems are classified together. Resulting in broad classifications. On the other hand, many articles classified under PDSS, IDSS, and GSS described the approach the article researched.

Additionally, when reading the literature, alternative approaches were identified, such as *Adaptive Decision Support Systems* (ADSS) (Fazlollahi et al., 1997), which they define as a "[...] *DSS that support human decision-making judgements by adapting support to the high-level cognitive needs of the users, task characteristics, and decision contexts*" (Fazlollahi et al., 1997, p. 299). In Table 1, this paper was classified as IDSS, GSS, and KMDSS because ADSS utilises intelligent technologies such as machine learning for knowledge management on a group level. This illustrates that approaches within DSS can overlap at different domain or technical levels. Additional alternative approaches identified were Organisational Decision Support Systems (Santhanam et al., 2000) and Case-Based Reasoning Decision Support Systems (Adla & Noureddine, 2019).

Eight key issues for the DSS discipline are discussed in one of the selected pieces of literature (Arnott & Pervan, 2007). Here are the issues of *(1) Professional relevance, (2) Research methods and paradigms, (3) Theoretical foundations, (4) Role of the IT artefact, (5) Funding, (6) Inertia and conservatism, (7) Exposure in 'A' journals,* and *(8) Discipline coherence*. This paper does not aim to analyse whether or not these issues are still prominent within the DSS discipline. However, during the conduction of the literature review, some of the issues did show prominence. Table 1 shows that some DSS approaches are more prominent than others, an issue Arnott and Pervan (2007) discussed as *inertia and conservatism*. Here, they present that PDSS has been the most dominant approach within the DSS literature from the 1980s to 2004, which they argue illustrates a concern regarding how, when new approaches are added, older approaches remain in play, showcasing the conservatism within DSS literature, possibly resulting in a decline in importance (Arnott & Pervan, 2007). This conservatism is also shown in this paper's literature, as it is the same approach classified from the 1980s to 2024.

Another issue presented in this paper's analysis is *discipline coherence*. Within this issue, Arnott and Pervan (2007) argue that the DSS discipline consists of many different sub-fields—defined as approaches in this paper—illustrating a lack of coherence in some areas of the discipline. Table 1 demonstrates some coherence within the literature through mapping and classifying, as shown by the overlap between references. However, not all approaches overlap, making it difficult to compare them, which illustrates that a coherence issue still exists within the discipline.

5 Findings

This section presents the key findings by analysing the selected literature through mapping and classification, as per the activities in the hermeneutic literature review framework. Based on the six DSS approaches defined by Arnott and Pervan (2014), the following section will present how each ap-

proach is determined through the literature. In addition, this section will also present business analytics, as the analysis has illustrated that this is a rising concept within DSS literature.

5.1 Personal Decision Support Systems

Personal Decision Support Systems (PDSS) are systems developed to facilitate one or a small group of decision-makers (Arnott & Pervan, 2007). One of the original approaches towards DSS, which arrived with the introduction of the personal computer, supported technical and nontechnical decision-makers to gain insights that could support their decision-making processes (Hackathorn & Keen, 1981). With the small scale of this approach, decision-makers can directly conduct tasks and provide complete control of the system to a minimum of users (Hackathorn & Keen, 1981). This approach excels in processes where information is needed quickly, with no issues allowing the system to run daily (Mann & Watson, 1984).

Even though this DSS approach originated with the dawn of the personal computer, it is still widely used. It remains integral to implementing user-built models and data analysis and is often used to support strategic decision-making (Arnott & Pervan, 2012).

5.2 Group Support Systems

Whereas PDSS focuses on supporting individual decision-makers, Group Support Systems (GSS) facilitate decision-making between a larger group of decision-makers (Arnott & Pervan, 2014). Within this group of individuals, who all engage in different interrelated tasks, GSS provides a system to facilitate the interactive sharing and utilisation of data (Hackathorn & Keen, 1981; Rathwell & Burns, 1985). An essential distinction of GSS is that it does not consist of PDSS for each group member, which is then linked together, but is a singular system that supports the whole group, often through the implementation of meeting systems (Rathwell & Burns, 1985; Eom et al., 1993; Arnott & Pervan, 2012). These meeting systems allow groups to communicate and share information electronically, replacing or supplementing verbal interactions (Dennis et al., 1997).

5.3 Negotiation Support Systems

Negotiation Support Systems (NSS) operates within a group structure, like GSS. However, what distinguishes this DSS approach is that it implements a system focused on facilitating negotiations (Rangaswamy & Shell, 1997). NSS provides support for groups that are involved in negotiating problems and processes. Having many similarities with GSS, NSS initially functioned as a subcategory within GSS. However, with different needs associated with preparing for negotiations, it was defined as its own DSS approach (Arnott & Pervan, 2005). Through NSS, electronic systems support negotiating parties by preparing and ordering the negotiation processes (Yang et al., 2009). With these systems set in place, these processes can become more manageable and comprehensible for their users (Delaney, 1996).

5.4 Intelligent Decision Support Systems

Intelligent Decision Support Systems (IDSS) apply artificial intelligence techniques to DSS (Remus & Kottemann, 1986; Arnott & Pervan, 2008). These systems are classified into two categories, the first being the use of rule-based expert systems for decision-making. The other is the implementation of statistical models, such as neural networks, for decision-making (Turban et al., 2005). These techniques support the decision-making process through statistical models (Pieptea & Anderson, 1987). Thus, to ensure the successful implementation of IDSS, data must be processed and stored in databases, which allows users to implement the systems. Because of these success criteria, expert knowledge allows for data storage and analysis (Remus & Kottemann, 1986). Through IDSS, decision-makers can analyse structured and unstructured problems as the statistical models allow for ex-

ploring these data types (Pieptea & Anderson, 1987). Through IDSS, decision-makers can thus incorporate human and machine intelligence to support their decision-making, automating some of the processes through artificial intelligence (Döppner et al., 2016).

5.5 Business Intelligence

Business Intelligence (BI) defines systems that utilise data and analytics to support decision-makers at all levels of an organisation through large-scale support systems (Arnott & Pervan, 2008). Being an emulsion of different DSS approaches, such as Executive Information Systems (EIS) and data warehousing, BI takes many systems under its wings. Arnott and Pervan (2014) argued for this combination of DSS approaches as they believe it more clearly expresses the actual use of executive-wide DSS today. As this paper utilises their categorisation of DSS approaches, it will also view BI as the modern interpretation of EIS and Data Warehousing.

Through BI, decision-makers access tools and techniques to analyse data to support organisational decision-making across environments (Arnott & Pervan, 2008; Demirkan & Delen, 2013). As data is an essential resource for successful BI, organisations must implement database management systems to store and handle large volumes of data (Demirkan & Delen, 2013). Thus, well-incorporating data warehousing into their systems is essential. The increasing availability of data provides the foundation for the growth of BI (Lycett, 2013).

5.6 Knowledge Management-Based Decision Support Systems

Knowledge Management-Based Decision Support Systems (KMDSS) are support systems that support managerial decision-making through knowledge storage and application by singular or organisational-wide decision-makers (Gintzberg, 1978; Arnott & Pervan, 2014), tasking these systems with multiple functions in multiple areas of the decision-making process, with generalised support (Gintzberg, 1978). The KMDSS are implemented with the model of the manager's role in mind, catering to their involvement in its implementation (Gintzberg, 1978; Hogue & Watson, 1983; Eom et al., 1993). The system often incorporates data management, modelling, data analysis, and adoption through user-friendly approaches (Meador et al., 1985).

5.7 Business Analytics

Business analytics (BA) is a longstanding research area in Information Systems that supports decision-making through data analysis (Holsapple et al., 2014; Watson, 2011). Due to its longevity, many tools and techniques have been developed to support decision-makers in generating insights from data, and these techniques are only getting more advanced (Phillips-Wren et al., 2021; Holsapple et al., 2014).

Designing and implementing systems that provide decision-makers with evidence-based insights remains a pivotal area of research (Grover et al., 2020). To support decision-makers, BA assists in handling the growing need for data analytics. This process has significantly changed over time, evolving from structured numerical data neatly placed in databases to unstructured data collected in real-time from various sources (Müller et al., 2018). Incorporating machine learning models, among others, to tackle growth in data volume, BA has solidified itself within Information Systems as a tool to enhance decision-making through data and ML resources (Müller et al., 2018; Phillips-Wren et al., 2021).

BA has recently increased in popularity in academia and industry (Beckwith, 2020). This increase could derive from its capabilities to determine business decisions based on large volumes of data (Trkman et al., 2010). Thus, with the increase in data volume seen in the last couple of years, BA could be shown to only increase in application and popularity (Phillips-Wren et al., 2021; Liebowitz, 2013). BA's popularity could also be attributed to its increasing adoption in tackling emerging business process challenges (Holsapple et al., 2014).

Because of its popularity within information systems, BA has several different definitions, often to fit its applied domain (Trkman et al., 2010). However, for this paper, we are going to utilise the definition forwarded by Holsapple et al. (2014): "*We adopt a general core characterisation of business analytics*

as being concerned with evidence-based problem recognition and solving that happen within the context of business situations" (Holsapple et al., 2014, p. 134). In this article, the authors derive this definition from a literature review that took patterns from 18 different definitions and simmered them down to this definition. However, as presented in other definitions of BA (Holsapple et al., 2014), it is the gain in insights and decision-making based on data or *evidence-based*, which is the critical aspect of BA that this paper draws.

As part of conceptualising this definition of BA, Holsapple et al. (2014) also present three dimensions that can support BA research. (1) ***Domain*** refers to the area in which BA is applied, (2) ***Orientation*** refers to the goal that wishes to be achieved through BA, and (3) ***Technique*** refers to how the BA are performed (Holsapple et al., 2014). Comparing the three dimensions with the architecture of DSS (Phillips-Wren et al., 2021), *domain* compares to the DSS approach, *Orientation* describes the decision-maker or user of the system, and *technique* defines the analytical tools used for data analysis.

6 Insights and Discussion

6.1 The Nesting Challenge of the DSS Literature

This paper defines the nesting challenge as oversaturating the number of DSS approaches by continuously creating new approaches to cover specific use cases. Within DSS, several approaches cover different decision-making processes based on areas of analysis and technological implementation. Several authors have interpreted DSS approaches (Locander et al., 1979; Remus & Kottermann, 1986; Fazlollahi et al., 1997; Abassi et al., 2016). The six approaches presented in Section 5 cover both approaches in which DSS is applied (PDSS, GSS, and BI) and explain the techniques used (IDSS, KMDSS, NSS, and BI). Defining the approaches between techniques and domains shows that not all approaches are comparable, as they focus on different areas within the system. This raises the issue of determining the appropriate approach for designing and applying specific techniques within specific domains. For instance, deciding which approach would be best suited for implementing machine learning solutions at an executive level is important. This example would be classified as using the IDSS approach, as it involves AI solutions for decision-making. However, the BI approach would also be utilised, as this approach incorporates Executive Information Systems (EIS), a sub-approach within BI. A different way to classify the example would be not to specify any approach and to define the system as DSS, as shown in the findings section, one of the most prominent classifications of the literature. However, this definition might need to be narrower and would thus be disconnected from practice (Arnott & Pervan, 2007). This highly reflects the *discipline coherence* issue forwarded by Arnott and Pervan (2007), in that the classification of different DSS approaches at various levels of abstraction makes it difficult to maintain discipline coherence. Thus, this paper argues that one reason for the issue of discipline coherence is that the DSS discipline tries to cohere the discipline through approaches that do not cover the same area. This paper argues that one way to solve it is to embrace the fact that not all approaches can be compared equally, as they do not cover the same areas within the system.

Another way to classify the example of the IDSS and BI classification example would be to combine the two into one approach. A trend in the DSS literature, as highlighted in section 4.3, is to create a new approach that combines the approaches, as seen in Fazlollahi et al. (1997). Here, Adaptive Decision-Support Systems are presented as a DSS approach that combines elements of IDSS, GSS, and KMDSS. Thus, for this example, a new approach would be created that defines DSS and applies AI at an executive level. However, this might quickly create oversaturation within the DSS approaches. This trend highlights a possible challenge of nesting within the DSS discipline. By oversaturating the number of approaches, it could be shown to dilute the literature by making it non-comparable, as each DSS is defined as being different, further strengthening the issue of discipline coherence. This is illustrated in the analysis section of this paper in the way that several articles were shown to cover areas associated with other approaches without stating it as being of that approach. This is evident in Adla and Neureddine (2019), as this paper has been categorised as GSS and IDSS without it being specified in

the paper. Instead, the paper defines a new approach - Case-Based Reasoning DSS (CBR-DSS) - that, among other things, covers group decision-making through AI solutions (Adla & Neureddine, 2019).

However, if we define the creation of new DSS approaches as an issue, then calling it an issue could strengthen inertia and conservatism and hinder change within the DSS discipline (Arnott & Pervan, 2007). Creating new approaches is, however, not shown to solve this issue, as they are often not used widely within the discipline, which is why this paper identifies the creation of newer approaches as an issue. One way to solve this is by challenging how the different DSS approaches are utilised. Accept that not all approaches can be compared and that they explain very different areas within the systems.

6.2 Business Analytics in Decision Support Systems

DSS have a broad and diverse academic history, with many approaches toward supporting decision-makers utilising computer systems. However, since its inception, data analytics has always been at the forefront of DSS (Todd & Benbasat, 1987; Finlay & Forghani, 1998). Likewise, BA is also grounded in a data-centric approach. The tools and techniques within BA share many similarities with DSS, as both deploy statistical methods and data mining for their data analysis (Phillips-wren et al., 2021). Similarly, DSS and BA share their view on supporting decision-makers and their business needs in knowledge acquisition (Abassi et al., 2016). As such, this paper wishes to discuss how these similarities can support the aforementioned nesting challenge. Drawing from the dimensions *domain, orientation,* and *technique* by Holsapple et al. (2014), this paper wishes to discuss how these dimensions could support the previously discussed way of tackling the nesting challenge.

BA's *domain* dimension refers to the specific field or context in which it is applied. This dimension is crucial in understanding the different approaches to decision support systems. For instance, EIS, GSS, and PDSS are three distinct approaches that define the space in which DSS is applied. They cater to different needs, whether supporting organisational-wide changes, facilitating group interactions, or aiding individual decision-makers.

Orientation is the direction in which the BA is applied through different taxonomies, thinking of BA as descriptive, predictive, or prescriptive (Holsapple et al., 2014). Within DSS, these decision-making orientations are mainly tasked to different actors supported by DSS (Phillips-Wren et al., 2021). These actors can have different roles, from technical experts or data scientists to business users' more managerial decision-making strategies. Decision-makers mainly control DSS's orientation.

The last dimension of the *technique* refers to the data analytics performed, whether through technology-based or practice-based techniques, differing based on the specific mechanisms needed (Holsapple et al., 2014). This dimension highly reflects the DSS approaches of *BI, IDSS, KMDSS, and Data Warehouse*, as these approaches also define the specific tool applied for decision-making support rather than the field in which it is applied.

This paper views the different DSS approaches through the dimensions of BA and argues that not all approaches cover the exact dimensions. PDSS, EIS, and GSS describe the domain in which the systems are implemented. In contrast, IDSS, BI, KMDSS, and Data Warehousing describe a technique or technology applied in the system.

Utilising the dimension of BA, this paper thus argues for a split in ways DSS define its approaches to encapsulate the intricacies of DSS. IDSS, BI, KMDSS and Data Warehousing define the technique rather than the domain to which the DSS is applied. Thus, these three systems could all be categorised as EIS, GSS, and PDSS based on the field in which they are applied. By splitting it up into Domains and Techniques, the DSS taxonomy could be more precise, allowing for investigation of different technologies utilised for decision-making within various domains, making the research more accurate, as clear definitions are applied. By having IDSS as a technique and PDSS, GSS, and EIS as domains, researchers can precisely state which domain and technique they use rather than define a whole new approach to using AI for PDSS. Through the BA dimensions, this paper proposes one way to handle the oversaturation of the DSS discipline with nested approaches. Thus, a more coherent DSS discipline is ensured, as it allows for a way to define the knowledge areas that a designed DSS would cover clearly. In defining the domain and technique approaches, existing DSS approaches must be divided

by, for example, splitting BI into its original parts of Executive Information Systems (EIS), BI, and Data Warehousing. As shown in Table 3, the DSS approaches presented in Section 5 are divided into *domain-specific* and *technique-specific* approaches. This paper argues that BI needs to be split into its previous parts, as it allows the techniques of BI and data warehousing at a personal, group and executive level. Allowing for defined DSS approach domains and techniques, this paper argues that DSS literature can become more specified within the system areas it is designed to support.

Domain-specific		Technique-specific	
Approach	Definition	Approach	Definition
PDSS	Systems that are developed to facilitate one or a small group of decision-makers (Arnott & Pervan, 2007	IDSS	Systems that apply artificial intelligence techniques to DSS (Remus & Kottemann, 1986; Arnott & Pervan, 2008).
GSS	Systems facilitate decision-making between larger groups (Rathwell & Burns, 1985; Eom et al., 1993; Dennis et al., 1997).	NSS	NSS provides support for decision-making that involves the negotiation of problems and processes (Arnott & Pervan, 2005).
EIS	Systems are applied on an organisational level (Arnott & Pervan, 2005).	BI	Systems that utilise data analysis for management reporting (Arnott & Pervan, 2005)
		Data Warehousing	The development of systems of databases for supporting decision-makers. (Cooper et al., 2000)
		KMDSS	Systems that support managerial decision-making enhance knowledge application and storage (Gintzberg, 1978)

Table 3. Domain- and Technique-Specific Approaches in DSS Litterature

7 Conclusion and Further Research

This paper examines the different approaches within the decision support systems (DSS) discipline and how they interact with each other. Following the hermeneutic literature review framework, it explores the DSS literature by showcasing six approaches and how they overlap. In addition, the literature review highlights current trends within the discipline, including the rising trend of business analytics, and discusses the challenge of nesting approaches within the DSS discipline. This results in the proposition that DSS approaches should be redefined to incorporate either the domain or technique of decision-making, as inspired by the dimensions of Business Analytics (BA). In doing so, a more concise taxonomy within the DSS discipline will be created. Thus, this paper contributes to the information systems (IS) literature by showcasing how DSS approaches differ and subsequently presents a new perspective to create coherence in the discipline.

Drawing from the dimensions of BA to structure the areas within DSS approaches alludes to further possibilities for research in integrating BA into the DSS discipline. Further research is needed to fully understand how the two disciplines interact.

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