Towards a Coordinative Theory for Flexible Work Collaboration

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Abstract

The workplace as we know it is undergoing profound change and the operational support mechanisms necessary to facilitate work activities are evolving along a number of distinct dimensions. An increasing number of these activities are inherently collaborative in nature yet we lack a fundamental understanding of the nature of the characteristics of the work that needs to be supported. The focus of this paper is to build an understanding of the key aspects of collaboration that are relevant to the operation of future work systems. This investigation aims to identify the fundamental dimensions underpinning multiparty work activities and to lay the foundations for a coordinative theory for managing flexible work – through IT artifacts and platforms that support the provisioning, facilitation and monitoring of collaborative activities involving the coordination of distributed and heterogeneous labour sources.

Keywords: Collaboration, Collaboration technology, Work practices, Work performance, Design/design science

Introduction

The workplace as we know it is undergoing profound change. Radical forces are reshaping the work environment and the notion of the “job” is receiving a degree of scrutiny as to both its form and its relevance at a level not seen since the days of Taylor (1911) when the formal organisation and optimisation of labour practices first came into focus and Marx (1930) when the nature of capital (both human and financial) and its relevance to the production activity was a central theme in western philosophy.

At the heart of these changes are a number of emergent mega-trends that are shaping the social and economic environment at various levels. A recent report by Deloitte Access Economics (2016) delineated four significant developments that will impact the nature of work in coming decades: globalisation of work, allowing it to be completed either partially or fully by workers in a distinct location to its final consumption or application; digital disruption whereby the application of technology to existing jobs and business processes fundamentally changes their format and even their viability; the disproportionate
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growth of an *ageing population* in most western nations resulting in a relative imbalance in the
demographic structure of society and its workforce; and the emergence of the *peer-to-peer (P2P)*
*economy* where technological platforms serve to directly link previously unconnected pockets of supply
and demand in a market in ways previously not possible or even deliberately disallowed by existing
market structures.

These changes will manifest themselves in a number of ways leading to a workforce, that is more digitally
connected, distributed, demonstrates differing levels of participation, and is engaged in direct peer-to-
peer interaction via platform technology. They have the potential to reshape the labour market in two key
ways: (1) they can directly substitute for labour and (2) they can disrupt the way that work is conducted
(Centre for Economic Development of Australia 2015). Indeed, the likelihood of the widespread
technological automation of jobs and its potential to impact even professional and technical sectors
previously thought immune to such displacement has received broad coverage in both the academic and
popular press (Ford 2015; Frey and Osborne 2017) as has the potential opportunities that broad
deployment of robotics and digital technologies offer (Brynjolfsson and McAfee 2014). The likely
consequences of such technologies in practical terms however is more mixed – some jobs will be displaced
and others created, however the real opportunities lie in effectively managing this tension between
obsolescence and emerging need (Willcocks and Lacity 2016).

What is clear is that the traditional notion of the “job” (which in its current form stems from the industrial
revolution) is set to markedly change (Dunlop 2016). Rather than the long-term, singular and somewhat
patriarchal relationship between employee and employer, there are a range of social, economic and
technological drivers of change that will affect future business models for organisations and most
significantly the nature of employment (World Economic Forum 2016). The broad availability of
telecommuting facilities, co-working spaces, virtual teaming arrangements, freelancing and online talent
platforms will fuel a trend towards more flexible work arrangements and promote the causes of the
independent work who provides services to multiple employers, often sourcing opportunities directly via
P2P markets and being sought out for – and indeed rewarded for – their unique capabilities (Hajkowicz et
al. 2016). The position of the independent worker will be further fuelled by global infrastructure and
employment marketplaces. These will encourage workers to further specialise their skills as their ability
to connect allows them to capture further value and deliver it directly to end-customers. Such contingent
work could approach 50% of the US workforce within a decade (StartupAUS 2016). The individuals and
companies who will be best positioned to succeed will be those who are able to embrace collaboration in
its various forms (Hajkowicz et al. 2016). Critical to the development of this ability will be two key future
workforce skills: social intelligence and virtual collaboration (Institute for the Future 2011) as the nature
of work will increasingly involve coordinated and unstructured multi-party activities.

Over the years, a variety of organisational management theories, concepts and techniques have emerged
not only in strategy and planning practices, but also the operationalisation of workforce collaboration.
Workforce collaboration entails the interactions, through a variety of means, by which workers are
sourced, recruited and coordinated in work, the ways that units and groups are organised and coordinated
in undertaking work, and the ways in which resources are used in work activity (Jasperson et al. 2005). At
its heart, workforce collaboration – ranging across different degrees of formality, structureness of
interaction and forms of communication media – is supported by typically automated coordination of the
various resources and activities involved in work management (Georgakopoulos et al. 1995). Different
technologies have emerged and evolved to support different aspects of coordination in and across
organisations.

Directory systems support the management of structural aspects of organisations, namely organisational
resources, roles, units and reporting lines, which include references to IT systems as specialised resources,
based on standards (e.g. X500 and X507). Information about organisational structures is then employed
by a variety of applications concerned with referencing resources for different activities. Behavioural
aspects of work coordination are addressed by workflow management and business process management
(BPM) systems (Weske 2012), which allow business processes to be modelled, executed and monitored,
and which reference organisational resources and IT systems as part of their underlying process models.
Collaborative or groupware technologies (e.g. Sharepoint), extend the focus of work behaviour to more
flexible interactions between individuals and groups in organisations, making use of information sharing,
human communications and other forms of shared interactions in supporting team collaborations in
organisations, while drawing upon workflow management, document and content management, task management and other process-aware information systems. Enterprise systems (Magal and Word 2013) provide domain-specific support for structural and behavioural aspects of work areas in managing businesses: accounting, human-resources management, supply chain management, customer-relationship management etc. Project management systems provide a focus on typically generative aspects of businesses, i.e. dedicated endeavours that coordinate resources and activities for producing work systems, artifacts, insights or results which can be subsequently refactored into work systems (e.g. development of new software applications).

Although, coordinative technologies underpinning the work environment have developed from distinct needs and conceptions, uncertainties exist as to how they can be extended to, and become better integrated for, supporting work coordination in unfolding and future work environments. The challenge has been apparent for some time now, as indicated by Heath and Luff (1991, p. 65), “we still have relatively little understanding of the organisation of collaborative activity in real world, technologically supported, work environments”.

Indeed, cast against prominent theories of work coordination, the emerging contexts of work highlight significant shortcomings. Future collaborative work entails broadened and more open organisational boundaries of businesses, extending beyond their current trend of forging globalised partnerships, to the establishment of digital communities in support of flexible sourcing of skills and resources. As an example, the use of crowd-sourcing in commercial organisations is leading to flexible work processes through the crowd and engaging consumers in traditionally encapsulated work, e.g. product/service co-creation and co-delivery models through social network/media capabilities. A further disruption is robotic automation, which is rendering otherwise passive resources into active agents which, to a certain extent, possess similar coordinating capabilities to human-to-human interactions.

These and other changes to work environments have two major implications for future work practice and thus for the extensions needed in coordinative theory, as apparent in classical Activity Theory (Engeström 2014a). Firstly, the organisational context for workers is extended to wider partnerships of organisations, including aligned communities, that are a source for the supply of micropartners for organisations. Thus, work boundaries need to be distinguished between those required for internally sensitive work versus more flexible boundaries in which open work participation can occur within and across enterprises. Secondly, digitised material resources such as ‘intelligent’ agents or robots and highly interactive objects such as those found used in the Internet of Things, implies the need for consideration of otherwise passive objects of work as active subjects, i.e., the breaking of static dichotomies of passive/active resources and unintelligent objects/intelligent human agents.

More generally, the notion of the ‘job’ will increasingly transmogrify into an ongoing sequence of short and medium work assignments with work participants potentially engaged in multiple work activities for distinct organisations at a given time. Many of these work activities will be inherently collaborative in nature and, although the enabling infrastructure and the underpinning economic environment to support this fundamental change in the work environment is gradually moving into mainstream society, we lack a fundamental understanding of the nature of collaborative work which needs to be supported.

Motivated by the assertion that the “design and development of collaboration technologies should be rooted in a thorough understanding of individual, group, and organisational work practice” (Poltrock and Handel 2010, p. 98), in this paper, we investigate the fundamental aspects of an integrated coordinative theory through a broad examination of the group work and team work literature. On the basis of five widely accepted models for productive work conduct, we synthesis 21 distinct dimensions of collaborative work that can subsequently serve as the basis for an integrated model for collaborative labour enterprises.

In conducting this research, we particularly focus on what it means to collaborate in the context of emergent work activities. Traditional work management systems view work activities as structured, atomic units undertaken by fixed populations of actors, frequently on a singular basis (Russell et al. 2016). However, this abstraction does not correspond to the reality of the modern work landscape where work activities evolve and are often undertaken in unforeseen ways by groups of workers in collaboration with each other. To validate the applicability and comprehensiveness of these dimensions, we have used them as the basis for describing three forms of collaboration that arise in practice. We have also used them to conduct a high-level analysis of three current workplace technologies to determine the extent of current
support for collaboration. Finally, we analyse the findings of our investigations and make a series of recommendations and propose a roadmap for future collaboration support.

**Approach**

The focus of this research initiative is to build an understanding of the foundational aspects of collaboration, specifically coordinative aspects, which are relevant to the operation of future work systems. As the constituent activities embodied in and supported by these systems are inherently collaborative in nature, this investigation focuses on the identification of the collaborative dimensions underpinning multiparty work activities and aims to lay the foundations for a coordinative design theory that can assist in the development of IT artifacts and platforms supporting the provisioning, facilitation and monitoring of collaborative activities involving the coordination of distributed and heterogeneous labour sources.

As the focus of our investigation is on better understanding the constituents of collaboration with a subsequent view to further improving our ability to support such practices in ICT artifacts, we have pursued a Design Science Research (DSR) approach (Benbasat and Zmud 1999; Gregor and Hevner 2013; Hevner et al. 2004; March and Smith 1995; Pfeffers et al. 2006; Pfeffers et al. 2007) in our research. The ultimate aim of this work is to build a design theory (Gregor and Jones 2007) for supporting the underlying coordination of work collaborations, with a complete definition of the eight components (core and additional) required to provide a complete substantiation for the theory. The first stage of this research (which this paper will focus on) is the identification of the purpose and scope of the theory, and identification and validation of core constructs.

The approach for this investigation is modeled on the three cycle view of DSR (Hevner 2007) as illustrated in Figure 1. This approach ensures a balance between the relevance and rigour (Benbasat and Zmud 1999) of the approach whilst still retaining the core objective of delivering a research contribution that is useful to a broad audience of both IS theoreticians and practitioners (Gregor and Hevner 2013). The sequence of activities that comprised the overall research approach and the intermediate outcomes is illustrated in Figure 2.

![Figure 1: Research model of (Hevner 2007) instantiated with concrete inputs and outputs for our approach (presentation inspired by (Wynn et al. 2017)).](image)

The initial motivation for this research stemmed from domain analysis of current support for collaboration practices in work systems and the recognition that the demands of future work systems will require a more comprehensive definition of collaborative work and the associated work practices. This was further augmented by a series of assessments of multiparty activity support in process-aware technologies commonly used to automate work activities which found minimal levels of automation support for tasks involving more than one worker (Migliorini et al. 2011; Russell et al. 2016; Russell et al. 2005; Wohed et al. 2009). These include business process management systems, enterprise systems, collaborative/groupware technologies, project management and directory systems. These findings form part of the relevance cycle for this research initiative together with an initial high-level assessment of the extent of collaboration support in current technologies, an overview of which is captured in Table 1.

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**Table 1: Relevance assessment of current IS technology support for collaboration**

<table>
<thead>
<tr>
<th>Environment</th>
<th>Design Science Research</th>
<th>Knowledge Base</th>
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</thead>
<tbody>
<tr>
<td><strong>Input</strong></td>
<td><strong>Output</strong></td>
<td><strong>Input</strong></td>
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<tr>
<td>Domain analysis</td>
<td>Literature review of teamwork &amp; collaboration practices</td>
<td>IS theories</td>
</tr>
<tr>
<td>Relevant ICT technologies</td>
<td>Evaluation of collaboration via case studies</td>
<td>Foundations</td>
</tr>
<tr>
<td>People</td>
<td>Experience &amp; expertise</td>
<td>Scientific theories &amp; methods</td>
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<td>Organisational Systems</td>
<td>Meta-artifacts</td>
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<td>Technical Systems</td>
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<tr>
<td>Problems &amp; Opportunities</td>
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<td>Analysis of ICT technology capabilities</td>
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</table>

**Figure 1:** Research model of (Hevner 2007) instantiated with concrete inputs and outputs for our approach (presentation inspired by (Wynn et al. 2017)).

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To build a broad understanding of IS domain knowledge relevant to this research (as part of the rigour cycle), a review of widely accepted IS theories (from sources including https://is.theorizeit.org) was then conducted to identify those relevant to collaboration. Five theories were shortlisted as having a significant contribution and these were further examined to determine their specific means of operation and coverage. Investigation of these theories yielded a range of contextual design factors relevant to collaborative practice and provided the basis for an initial set of collaboration dimensions. These details are included in the IS Theories section and a subsequent assessment of their contribution to specific areas of collaboration support is included in Table 1.

The design cycle of this research initiative sought to validate the relevance of the various design contextual factors from these theories as the basis for actual collaboration dimensions. A comprehensive literature review across 1203 research publications in the information systems, management, business, psychology and economics domains was undertaken to seek evidence for each of these collaboration dimensions. A dimension was considered to be valid if its applicability to multiple distinct scenarios presented in the academic literature could be established. This approach to the identification of recurrent, generic constructs is analogous to that utilised in the patterns literature (Alexander et al. 1977; Gamma et al. 1995; Hohpe and Woolf 2003; Russell et al. 2016). As part of this activity, this review also sought to identify recurrent concepts not previously identified in the five informing IS theories that were relevant to collaboration or related aspects of group work, team work or multi-party work coordination.

**Figure 2: Research approach for the identification and validation of the collaboration dimensions**

This review ultimately identified 21 distinct dimensions of collaborative practice – twelve arising from the assessment of IS theories (and validated by identification in the academic literature) and a further nine from the literature review alone. In conjunction with prior IS learnings in regard to enterprise landscapes, this then enabled the synthesis of lifecycle models for the work activity, workgroup and work participant entities. The adequacy of this set of collaboration dimensions was then assessed through their ability to precisely represent a series of twenty-two real-life collaboration case studies, three of which are presented in their entirety in this paper. These results are summarised in the Scope of Operation and Collaboration Dimensions and Scenarios sections.

**Informing IS Theories**

There is no single theory of collaboration or collaborative practice relevant to the IS domain, however there are a range of widely accepted IS theories that inform the discussion in regard to what the core components of such a theory should be. In this section, we examine five significant IS theories that have a contribution to the building of a theory for collaboration.

**Activity Theory**

At the heart of collaborative groupwork is the notion of the work activity that provides the focal point for such efforts. Activity Theory (Bardram 1998; Engeström 1999; Engeström 2014a; Kaptelinin and Nardi 2012; Kuutti 1991; Nardi 1995) presents a conceptual foundation for analysing and understanding human activities in a specific context that is widely utilised in the Information Systems field. One of the significant advantages offered by Activity Theory is its focus on practice and its ability to address practical needs rather than just offering a theoretical description of human activity (Nardi 1995). For this reason, it
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presents an ideal basis for describing the orchestration and execution of collaborative groupwork activities. Motivated by the work of (Marx and Engels 1970), it triggered the development of a “theory of activity” (subsequently to be become more generally known as Activity Theory) as part of a larger effort to develop a new basis for psychology based on Marxist philosophy (Kaptelinin et al. 1995; Wertsch 1981). Key contributors to this effort included Vygotsky, Leontiev and Luria.

Vygotsky, a practicing psychologist, established the field of Cultural-Historical Activity Theory focusing on the study of situated social interactions underpinning collective human activities (Nardi 1995; Vygotsky 1981; Vygotsky 1986) and identified the notion of the mediated action (Vygotsky 1978) where a human subject acts on an object by utilising various kinds of tools (e.g. physical instruments, language, mental models). In other words, these tools mediate the human action being undertaken in various ways. Vygotsky differentiates between two types of tools: technical ones that support the manipulation of physical objects and psychological tools that enable humans to influence others (e.g. email) or even themselves (e.g. personal calendar). Tools have a duality in function: on one hand, they can increase our available options for manipulating and transforming different objects, but on the other the object can only be perceived and manipulated within the limitations set by the tool. Thus mediating tools can have both an enabling and a constraining function (Kaptelinin et al. 1995).

Many of the fundamental concepts which underpin the modern conception of Activity Theory are based on the work of Vygotsky, however it was his student (and subsequently his colleague) Leontiev who first developed a coherent and integrated framework for the domain (Leontiev 1974; Leontiev 1978; Leontiev 2009) which enabled analysis of the structure and function of activities. Key features of Leontiev’s framework (Kaptelinin and Nardi 2009b; Kuutti 1995; Wertsch 1981) include:

1. Unity of consciousness and activity: The human mind is formed by and exists as a consequence of human interaction with the environment. It can only be investigated in the context of activity.
2. Object-orientatedness: All human activities involve a directed relationship from a subject (which may be an individual or a collective entity) to an object in a specific social context. They are undertaken with some objective in mind and are differentiated by the object on which they operate.
3. The hierarchical structure of activity: An activity, including the associated subject-object relationship, can be analysed at three distinct levels: activities, actions, and operations as illustrated in Figure 3. Activities are made up of goal-directed actions taken to achieve a specific object. Actions are conscious events implemented through automatic operations. Different actions may be undertaken to achieve the same goal. Operations do not have specific goals; rather they provide a basis for coordinating actions to meet with current situational needs. Goals can be (repeatedly) broken down into lower-level goals.
4. Internalization–Externalization: There is a distinction between internal and external activities. Internal activities (e.g. internal thought processes) cannot be understood if they are analysed separately from external activities (e.g. allocated tasks), because there are mutual transformations between each of them. External activities can be transformed into internal ones thus providing a means for humans to simulate potential interactions without actually undertaking them.
5. Mediation: Human activity is mediated by tools in a broad sense. Tools are both created and transformed during the development of the activity itself and convey specific cultural influences.
6. Development: Activity theory considers development not just as an object of study, but also a general research methodology. Development motivates the continuous assessment and enhancement of practice. Activity theory is intended to be an expansive means of enquiry and rather than prescribing a single method of study, it examines the problem domain and then progresses to the selection of a suitable method for the context of inquiry.

Leontiev’s conception of an activity is illustrated in Figure 4. It can be viewed in terms of a mediated interaction (typically using some form of tool or instrument) from a subject to an object with the objective of achieving some specific outcome.

Although it was incredibly influential in the Soviet scientific establishment, Activity Theory was largely unknown in the west until it was taken up by Scandinavian researchers in the mid 1980’s (Kaptelinin et al. 1995). Engeström was one of the first western researchers to build on the Soviet foundations and in his seminal work Learning by Expanding (Engeström 2014b) proposed a significant expansion to previous conceptions of an activity (illustrated in Figure 5) as an individually mediated action by recasting it as a collective activity system where the mediated interaction between subject and object is recognised as
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occurring in the context of a social setting or community which has associated with it a set of implicit and explicit rules governing how the subject operates and interacts with the broader community (e.g. accepted work practices, policies) and also a division of labour which guides how the object is transformed in order to achieve the desired outcome (e.g. position descriptions, job roles, organisational hierarchies).

This reconceptualisation of the notion of the activity has had great significance extending the application of Activity Theory beyond its original psychological focus into a range of new disciplines including work design and transformation (Bardram 2000; Engeström 1999; Engeström 2000), human-computer interface (HCI) design (Bodker 1989; Kaptelinin and Nardi 2009b; Kaptelinin and Nardi 2012; Kuutti 1995), computer supported collaborative work (Bardram 1998; Kuutti 1991; Kuutti and Arvonen 1992), system development methods (Quek and Shah 2004), information systems research (Crawford and Hasan 2006; Kuutti 1991), and tools and methods development (Bardram 1998; Bardram 2005; Kaptelinin and Nardi 2009a; Mwanza 2002).

**Coordination Theory**

Coordination Theory is a framework developed by Malone and Crowston (1994,1991) that provides a basis for the interdisciplinary study of coordination which it describes as the process of managing dependencies between activities. In order to do this, it characterises the different types of dependencies that can exist and then identifies specific coordination processes that can be utilised to manage them. The framework is based on four main elements: goals, activities, actors and interdependencies. Amongst these elements, the following dependencies are identified (Crowston 2003; Malone and Crowston 1991) and potential approaches to their resolution are outlined from a range of distinct scientific and organisational domains

- Managing shared resources - where multiple activities require the services of and need to share some limited resource, some form of resource allocation mechanism is required to deal with the interdependencies between them;
- Managing producer/consumer relationships - where one activity utilises a commodity or service produced by another activity, a means of managing the dependency is required. Three distinct types of dependency may need to be catered for:
  1. Prerequisite constraints - a sequencing requirement may exist between producer and consumer such that one must complete before the other can commence
  2. Transfer - the transport of the shared resource between producer and consumer needs to be catered for
  3. Usability - the output from the producer needs to be provided to the consumer in a form that it can directly utilise
- Managing simultaneity constraints - the dependency between the two activities may require they are executed concurrently or that they be prevented from executing concurrently
- Managing task/subtask dependencies - where a dependency exists amongst a group of activities that are all contributors to some overarching goal. The goal can be decomposed across the group of activities (possibly resulting in further subtasks or subgoals). Another alternative is goal identification where a dependency is recognised across a group of actors or activities that are all contributing to the same outcome or goal.

Coordination Theory has been applied in a range of distinct areas including organisational process design (Crowston and Osborn 1997; Malone et al. 2003), process redesign (Crowston 2003), collaboration

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*Figure 3: Activity Theory hierarchy based on (Kuutti 1995)  Figure 4: Mediated activity based on Leontiev's conception (Kuutti 1991)  Figure 5: Engeström's activity system (Engeström 1987, Engstrom 2014)
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technology development (Malone and Crowston 1990; Olson et al. 2013) and temporal coordination (Bardram 2000).

**Situated Action**

The notion of the Situated Action was first introduced by Suchman (1987) in recognition that the actions pursued by actors in a given circumstance will be strongly influenced by the context in which they are situated. Although a formal plan may exist which seeks to describe alternative choices of action available to the actor in a given scenario, it will be viewed more as a source of knowledge or a guiding resource that can be utilised by the actor in a given circumstance than a definitive set of instructions. As such, a dichotomy exists between the plan (also termed a “representation of action”), which is developed a priori as a sequence of actions to achieve some preconceived outcome, and the actor’s choice of action, which is intended to move them closer to some desired end state. The rationale of the situated action approach is that the course of action pursued by the actor is not something that precedes a specific event or circumstance but instead is something that emerges directly and in response to the immediacy of the encountered situation on the basis of the actor’s perception of the environment, available options and their internal knowledge set (Lave 1988; Suchman 1987; Suchman 2007). As such, the focus of the situated action approach can be identified as “the activity of persons-acting in setting” (Lave 1988, p. 177) where the setting can be viewed as the relationship between the interacting participants and the environment in which they operate. Key considerations of the approach are that it is responsive to the setting of the activity and recognises the “improvisory nature” of the actors involved (Lave 1988; Nardi 1996). Moreover, it retains a focus on individual actions and “collective aspects are not addressed explicitly” (Susi and Ziemke 2001, p. 283). In other words the emphasis is on what people actually do in practice with a consequential loss of focus on what “people want to achieve as a collective entity” (Hemetsberger and Reinhardt 2009, p. 989). Key features of the situated action approach include its emphasis on people and cognition occurring in actual, naturally occurring contexts, its emphasis on a data-driven rather than theory driven approach to investigation, a focus on communication and interaction (both between participants and the environment) as the means of building understanding and knowledge, and its overriding focus on developing understanding of how people make use of resources (both physical and conceptual) when engaged in purposeful action (Artman and Waern 1995).

**Distributed Cognition**

The theory of Distributed Cognition was developed by Hutchins (1995) as framework to explain how interactions between individuals, the tools and artifacts that are available to them and the environment in which they operate can lead to more significant cognitive accomplishments than a single actor could achieve. It views cognitive processes as distributed social phenomena embodied in real practices and occurring with reference to artifacts in the environment rather than being constrained by the mental and physical attributes of an individual participant as earlier theories of cognition had posited. As such, it offers the opportunity to develop an understanding of how socially shared and coordinated activities can achieve their required goals through the coordination of associated individuals and artifacts (Turner and Turner 2001). The approach has a particular focus on building an understanding of “persistent structures”, particularly artifacts and environmental objects, their representation and the changes they undergo (Nardi 1996). A key aspect of distributed cognition is its ability to scope the unit of analysis to the particular characteristics of the scenario under examination, this may range from the process of an individual participant through to the interactions between a group of participants, a set of tools, and their environment (Halverson 2002). Key assumptions of the approach that lead to unique insights during its use are (1) that the cognitive properties of a system comprised of several individuals differ from those possessed by any participating individual and (2) that the knowledge possessed by participants is both varied and redundant, spurring subsequent interactions and knowledge-sharing between participants that is beneficial to the achievement of their shared goals and objectives (Rogers and Ellis 1994). Subsequent research using the approach (Hollan et al. 2000) has further advanced the understanding of how the socially distributed cognition of a group is greater than that of its individuals, of how cognition is fundamentally embodied in the physical characteristics of the actors and work objects associated with a group, and that cognition cannot be viewed in isolation from the cultural environment in which a group operates. Distributed cognition has been successfully utilised for investigating the operation of a variety of complex, group-based work scenarios including navigation of aircraft and ships (Hutchins 1995; Hutchins...
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and Klausen 1996), software development teams (Samer and Lee 2000), engineering work practices (Rogers 1992; Rogers 1993), air traffic control (Halverson 1995) and telephone helplines (Ackerman and Halverson 2004; Ackerman and Halverson 2000).

Work System Theory

Work System Theory (Alter 2002; Alter 2006; Alter 2008a; Alter 2008b; Alter 2013) is an integrated method for capturing and reasoning about systems in an organisational context. It is premised on the notion of a “work system” constituting a “natural unit of analysis for thinking about systems in organisations” (Alter 2013, p. 75) where a work system is a system enabling human and non-human resources to undertake work activities using IT and other tools and facilities to deliver goods and service to customers. It encompasses the Work System Framework which identifies the nine main elements considered to describe a work system (processes and activities, participants, information, technologies, products/services, customers, environment, infrastructure and strategies) together with the Work System Lifecycle, a staged model for the design, development, implementation and operation of a work system. Subsequent extensions also include a series of design principles to guide the use of the method and a metamodel that provides a detailed specification of the framework. In essence, WST is an effective design method for work system definition, although it does not capture the fine-grained detail required to orchestrate collaborative, multi-party work activities.

Scope of Operation

In order to better discuss the broad range of potential collaboration scenarios that can exist, it is first necessary to provide a precise delineation of the business landscape in which the interactions occur. Figure 6 depicts a number of distinct collaboration scenarios (labelled 1 to 5). Work, as seen through organisational structures is held to operational responsibility by individuals in designated roles and managed through groups.

While workgroups, as such, coincide with organisational units, structural grouping of organisations have evolved and can operate concurrently for different management concerns. This can be seen through hierarchical reporting lines providing the more permanent organisational structure required to meet the organisational mission and goals, and functional, “matrix” structures created to flexibly leverage different parts of organisations for achieving transient goals supportive of broader organisational goals (Jones 2013). Workgroups are directly situated in functional structures while their participants are “grounded” through hierarchical organisational structure.

A further complexity of the structural context of work can be seen through the contemporary organisational structures of enterprises, which transcend individual organisational boundaries, to multiple organisations working in formal, semi-formal or informal business arrangements. In this setting, participants for workgroups can be drawn from different organisations (e.g. as evident in commercial or communal project teams).

Within the context of an enterprise, organisations may interact and cooperate in a broader field of endeavour. Examples of such collaborations include supply chains in the automotive or airline industries; clothing manufacturing, distribution and retailing; and agricultural production, processing and distribution of foodstuffs and related materials. Such alignments of organisations across a domain are sometimes termed business networks. Such contexts have led to different degrees of system visibility, to safeguard confidentiality, integrity, and managerial coordination.

As seen through various IS modelling references (notably (Falkenberg et al. 1996)), activities and tasks of work operate cohesively within business domains (e.g. transportation management) and are more widely coordinated through business environments. This delineation of organisational boundary is supported through enterprise systems (Magal and Word 2013) and major industry standards such as VICS and SCOR used in supply chain management (Ayers 2006). In other words, the internal systems boundary of a workgroup lies within the domain of the system, entailing individual participants drawn from one or more organisations, while the external boundary of the system involves an environment of external organisations with reduced visibility of organisational structure, loosely coupled interactions, and more constrained information access.
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Figure 6: Collaboration scenarios in the business landscape

Within the context of an enterprise, an internal work activity can be originated by one of the organisations associated with the enterprise. Such a work activity is an integral unit of work that needs to be completed under the auspices of the enterprise (although not necessarily by participant workers within the enterprise) and managed by a responsible party within the enterprise. In contrast, an external work activity originates from outside the boundaries of a given enterprise and may (or may not) be managed by a responsible party within the enterprise.

There are a variety of distinct scenarios (AXELOS 2011) in which a work activity could arise and be managed in the nominated business landscape as illustrated in Figure 6:

1. an internal workgroup can be formed within the context of a single organisation with participants drawn from a variety of organisational units (insourcing);

2. a workgroup could be formed in the context of an enterprise with participants drawn from a number of the organisations comprising the enterprise (a form of co-sourcing);

3. a workgroup could be formed in the context of an enterprise with participants drawn from a number of the organisations within the enterprise and also from organisations in the broader business domain (a variant form of co-sourcing);

4. a workgroup could be identified from an organisation in the broader business domain to whom a work activity could be assigned for execution; this phenomenon is also termed outsourcing; and

5. a work activity could be coordinated by a participant from an organisation in the enterprise but undertaken by a workgroup formed from self-selected independent participants in the domain; a phenomenon also known as crowdsourcing.

Each of these collaboration scenarios involves the convergence of a work activity with a suitable workgroup. The work activity may arise from within a given organisation or enterprise or it may originate from a source external to it. Similarly, the coordination of the work activity and the formation of the required workgroup may occur within the organisation or it may be facilitated either partially or wholly by external parties.

Collaborative work organisation

Each of these collaboration situations involves the interplay of three significant entities: the work activity, the workgroup and the work participant. Each entity exists independently and is subject to its own...
Towards a Coordinative Theory for Flexible Work Collaboration

The constraints that govern the range of allowable states in which it can exist. These states and the transitions between them provide the basis for a unique lifecycle for each of the entities. The lifecycles serve the dual purposes of both guiding the potential sequence of states for an entity and also providing the opportunity for unanticipated, contextually-nuanced interactions between entities at specific points in their lifecycle (Feldman and Pentland 2003). Particular courses of action may be influenced by the enterprise in which a work activity is sited, an individual participant in a workgroup or work activity context (Suchman 1987) or an entire workgroup (Hutchins 1995). From a general standpoint, the basis of the interactions between them is illustrated in Figure 7.

The interlinkages between these entities occur at three levels. First, in establishing how a collaborative work activity will be progressed, there is a relationship established between the work activity and the workgroup that will undertake it. This may occur in either direction - the workgroup may pre-exist and the work activity may be allocated to it, or the work activity may necessitate the identification or formation of a suitable workgroup.

Second, there is a relationship between the workgroup and the individual participants that are part of it. This involves the recognition of the need for the workgroup, determination of how it will be coordinated, recruitment of suitable participants, formation of operational arrangements for the group, conduct of assigned work and ultimately disbanding of the workgroup.

Thirdly, there is a relationship between the work activity and the individual workgroup participant who will undertake it (either a portion of it or the entire work activity). These three entities and their associated lifecycles provide the basis for describing the various factors governing the range of potential and actual operational considerations that apply to collaborative work activities. In the following sections, we will explore these potential configurations in more detail.

**Work activity dimensions**

The work activity is the basis of collaborative work practices. Its conduct follows the sequence outlined in Figure 8 in the context of a specific work environment. Depending on its origination, it may already have an assigned workgroup or coordinator or this may occur during the initial stage of the work activity lifecycle. (Note that aggregate refers to all parts of a work activity where it has already been subdivided).

The lifecycle associated with the work activity proceeds as follows. Initially there is a planning phase where the best approach to handling the conduct of the work activity in a group context is determined. Having determined the manner in which to proceed, the work activity is distributed to the workgroup or specific members of the workgroup, their commitment to proceeding with it (or selected parts of it) is secured and subsequent efforts to undertaking it commence and ultimately conclude. It is important to recognise that although the lifecycle is nominally portrayed in a linear form, in practice deviations from this sequence of steps are possible, particularly backtracking to earlier steps when the non-achievement required work activity or broader environmental conditions preclude progression to the next stage of the lifecycle (e.g. there are no available participants to distribute a work activity to, no participants are prepared to accept a work activity offered to them). The factors that impact the various state transitions serve to characterise the nature of the collaboration in the context of the work activity and, as such, are a key part of this investigation and are discussed later in the paper.

![Figure 7: Entities involved in collaboration work and conduct](image)

![Figure 8: Workgroup Activity Lifecycle](image)
Workgroup dimensions

The workgroup is the collective entity that provides the coordination and scheduling of the required resources and capabilities to undertake a work activity. A workgroup may have long-term standing and have incoming work activities assigned to it or it may be formed specifically in response to the needs of a work activity. The lifecycle associated with the workgroup is depicted in Figure 9.

The lifecycle proceeds as follows. The need for a specific workgroup is first identified during the work activity recognition stage, this leads first to the need to determine how the workgroup will be coordinated, and then how the participants required for the workgroup will be recruited. A key part of the latter activity is the determination of specific capabilities and resources that are required in order to tackle the work activity. Where it is identified that a coordinator is needed to direct the workgroup, an appropriate resource is then secured. The assumption of the four stages of the workgroup formation lifecycle is that they occur under the auspices of the enterprise that is handling the associated work activity. Subsequent stages of the lifecycle may also be handled in a similar manner, however it is more likely that where a suitable coordinator(s) is recruited, that they will manage them. Once a coordinator has been assigned to the workgroup, recruitment of required team participants can occur. This then allows the workgroup to move onto the actual planning and execution of the associated work activity. When this is complete, the workgroup can potentially disband, although for longstanding teams, it is more likely that they will be allocated other work activities.

The manner in which the various stages of the lifecycle proceed is determined by a number of underlying dimensions. These relate to the manner in which the workgroup is required to be formed and coordinated, and how specific work participants are identified from within the workgroup. The range of relevant dimensions is discussed in the Collaboration Scenarios & Dimensions section.

Work participant dimensions

The participant is the ultimate source of the actual labour associated with a workgroup and provides a range of distinct capabilities and the ability to harness required resources in order to conduct a work activity. The lifecycle associated with an individual within a workgroup is depicted in Figure 10.

The lifecycle proceeds as follows. Once a work activity has been assigned to a workgroup and appropriate planning and scheduling activities have been completed, the work activity (or a fragment of it) is offered or allocated to an individual participant. To indicate their preparedness to undertake the specific work activity they need to indicate their commitment to the workgroup coordinator. Once this has been done, at a time of their choosing, the participant can commence work on the activity and during execution can choose to further decompose it into sub-work activities which are then delegated to other participants in the workgroup, in turn triggering new instances of the workgroup participant lifecycle. Finally, and again at a time of their choosing, the participant can signal their participation in the work activity is complete. The manner in which the various stages of the lifecycle proceed is underpinned by the allegiances and remuneration relevant to specific work participants. These factors are discussed further in the Collaboration Scenarios & Dimensions section.

Figure 9: Workgroup Formation Lifecycle

Figure 10: Workgroup Participant Lifecycle
Collaboration Scenarios & Dimensions

The results of the literature review yielded 21 distinct collaboration dimensions as identified in Table 1. These dimensions were used to assess the degree of support for the concept in each of the five informing IS theories and also in three exemplars of current technology classes (workflow, project management and enterprise systems). In each case, it can be seen that the extent of collaboration support is limited.

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Focus</th>
<th>AT</th>
<th>CT</th>
<th>SA</th>
<th>DC</th>
<th>WS</th>
<th>WF</th>
<th>PM</th>
<th>ES</th>
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</thead>
<tbody>
<tr>
<td>WO: Work origin</td>
<td>Originating source of work activity</td>
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<tr>
<td>WAP: Work activity purpose</td>
<td>Type of work activity</td>
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<td>AS: Assignment strategy</td>
<td>Basis of work activity distribution to participants</td>
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<tr>
<td>WCS: Work communication scheme</td>
<td>Manner by which participants within a workgroup are made aware of their work obligations</td>
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<td>PC: Participant choice</td>
<td>The latitude that an individual workgroup participant has to accept or reject proffered work activities</td>
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<td>SI: Shared information</td>
<td>Extent of shared information between workgroup participants</td>
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<td>WGD: Workgroup dominion</td>
<td>Where the nexus of responsibility for a work activity lies</td>
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<td>WAFO: Work activity fulfillment orientation</td>
<td>Overall objectives for their conduct of a specific work activity</td>
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<td>DM: Distribution mechanism</td>
<td>How work units are to be matched up with participants for subsequent execution</td>
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<tr>
<td>WIC: Work item conduct</td>
<td>The degree of autonomy that workgroup participants have in their approach to completing or organising the completion of a specific work activity</td>
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<td>WIA: Work item atomicity</td>
<td>Whether, and on what basis, a work activity (or the work units making up the work activity) can be subdivided</td>
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<td>DT: Division time</td>
<td>The timing at which a work activity can be subdivided</td>
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<td>WAS: Work activity scheduling</td>
<td>The permissible execution sequences for fragments of a subdivided work activity by the participants in a workgroup</td>
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<td>CC: Commencement criterion</td>
<td>The means by which the commencement of a work activity can be determined</td>
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<td>CC2: Completion criterion</td>
<td>The means by which the completion of a work activity can be determined</td>
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<td>ICS: In-group coordination strategy</td>
<td>How the individual work units making up the work activity will be coordinated amongst participants and who will be responsible for managing their conduct</td>
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<tr>
<td>WGF: Workgroup formation</td>
<td>The approach to be taken to forming a workgroup and recruiting the necessary participants</td>
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<td>WGE: Workgroup involvement</td>
<td>The way in which workgroup participants are involved in a specific work activity</td>
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<td>SC: Selection criterion</td>
<td>The basis on which participants are selected to undertake a specific work activity</td>
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Case Studies

To validate the applicability of the collaboration dimensions, a range of real-world case studies involving coordination of multiple parties in achieving a shared, complex outcome was identified. A case study approach was selected as the validation mechanism for collaboration dimensions in accordance with criteria set by (Yin 2014). Such an approach is suitable for investigating “how” and “why” questions such as those relevant to the identification of the range of contextual factors applicable to collaboration across distinct settings. The descriptions of the various case studies are transparently available and represent legitimate instances of collaborative practice identifying the associated organisational structure and role designations for the different types of workers that are potentially involved. The collaborations are explicated in terms of distinct activities running over a significant period (months, years or ongoing), supportive of clearly stated goals and outcomes. Additionally, the descriptions of the collaborations outline information and artifacts that are used and produced and describe the formative aspects of team establishment, operation and interaction.

The collaboration dimensions were used to develop a description of how each of the specific case studies would be configured and potentially operationalised from a collaboration standpoint. The focus across the range of case studies undertaken was to confirm the applicability of the collaboration dimensions for delineating and capturing distinct collaboration scenarios in a meaningful and precise way that provided guidance for their subsequent conduct. In each of the 22 case studies undertaken, the collaboration dimensions were found to provide effective guidance for this task and a complete description of the specific collaboration scenario was able to be fully captured. Three of these case studies are included below along with identification of the various collaboration dimensions used to develop the description in each case.

Crowdsourced parliamentary expenses investigation

In 2009, The Guardian newspaper launched an innovative scheme1 to analyse the validity of MPs expenses claims (WO) by publishing 700,000 individual documents related to these claims and providing the ability for members of the public to review and comment on these documents. There was no centralised management of the scheme, members of the public reviewed and provided comment to the various disclosures on a voluntary basis. It involved a work item generated from a single internal source: The Guardian newspaper investigative scheme is essentially a problem solving (intellective) activity (WAP). Work activities that made up the investigation were offered to potential workgroup participants on a non-binding basis (AS,DM) via an open (market-based) channel which all participants and observers could view (WCS). Potential participants were free to select the activities they intended to work on at a time of their choosing but were not committed to undertaking an activity that they had indicated an interest in (PC,WIC). Once an individual had indicated a preparedness to undertake a work activity, the responsibility for doing so rested with them and was not shared with other potential participants (WGD) even if they had indicated an interest in working on the same activity. Any work that they undertook was communicated to all other participants and observers (SI). All work items posted by The Guardian for investigation could be undertaken in their entirety or be further sub-divided at any time (WIA,DT). The various work items could be commenced once they were posted on the publicly accessible website (CC) and could be undertaken in parallel by participants (WAS). There was a fixed deadline for the overall completion of the investigation (CC2) and during the time that it was running, the emphasis was to complete as many work activities as possible (WAFO). The work team for the investigation effectively self-assembled (WGF) and there was no inherent coordination of work undertaken by group participants. Participants were only involved in the aspects of the investigation that they chose to participate in (WGI) and there were no specific selection criteria for participants (SC), who were external to the work organisation (i.e., The Guardian) and were unremunerated for their efforts (PS,PR).

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1 See http://www.theguardian.com/news/datablog/2009/jun/18/mps-expenses-houseofcommons for full details of the operation of the scheme
Open source software development

The rise of open source software initiatives is one of the most prominent examples of large-scale collaboration amongst otherwise unrelated individuals. Fuelled by the ubiquitous availability of internet connectivity, open source development practices underpin the ongoing creation of a multitude of software offerings across a broad spectrum of application domains. The Apache Software Foundation which oversees the development of a number of widely utilised software offerings including its eponymous web server is taken to be representative of the range of approaches to open source collaboration. Full details of its standard development practices are described at http://community.apache.org.

Perhaps the most significant contribution of open source initiatives beyond the software that they provide is the large-scale structured collaboration processes and environments that they have established. The Apache software development processes is one of the most mature examples of this phenomenon providing the management infrastructure and practice for several hundred open-source projects. Development ideas, suggestions and bug reports are received by project teams from a variety of external sources (WO), evaluated on their merits, prioritised and ultimately they may ultimately be incorporated into a specific project’s code base. In this sense, the Apache open source development process can be considered to be a creative activity (WAP) in that it gathers and generates ideas for subsequent pursuit. Each project has a team made up of individuals with one of three associated roles: contributors who provide ideas and code for the project, committers who determine whether contributions to the code base should be incorporated and handle their inclusion, and the project management committee that oversees governance of the project. The team is self-assembled and self-managing (WGF) with promotion of contributors to committers or project management committee being determined by other team members. Team members are volunteers typically sourced from the software community (PS) and are not remunerated for their contributions (PR). There are no specific selection criteria that apply to team membership (SC). Also, there is no formal coordination of work within a project team (Deloitte Access Economics), rather individuals elect to undertake specific work activities at a time of their choosing from those identified as needing to be addressed (PC). Open work activities are offered to all project participants (AS,DM) through the project’s communication channels, similarly all progress and content information relevant to work activities is shared across the same channels and is visible to all team members (WCS,SI). When a team member indicates they will undertake a given work activity, they are individually responsible for its conduct in its entirety (WGD,WIC) and the expectation is that they will deliver a quality solution rather than focussing on a quick fix (WAFO). Work activities can be further decomposed into finer-grained work activities (WIA) as required at any stage during their conduct (DT). Where multiple team members work on a given work activity, they do so on an overlapping basis (WAS) at a time of their choosing (WGI). The commencement of any given work activity is implicit (CC), occurring when the first team member starts working on it. Completion occurs when a contribution is accepted into the project code base, generally this decision is based on a team vote (CC2).

Telemedicine in remote and war-torn locations

Telemedicine focuses on the use of communication and information technology to provide clinical healthcare over a distance. It is particularly suited to situations where the patient and medical practitioner are unable to physically meet on a timely basis. The international humanitarian non-government organisation Médecins Sans Frontières (MSF) is pioneering the use of telemedicine to provide specialist healthcare in war-torn and developing regions\(^2\). It does through a collaboration scheme that allows care teams in the field to rapidly seek additional expertise on individual cases from a range of medical experts around the globe. Requests originate from MSF teams in remote locations (WO) and are directed to one of three specialist coordinators who are responsible for assembling the team of relevant experts (WGF), both MSF and external doctors, located around the globe who can assist with the issue and managing it through to a satisfactory completion (ICS,PC). As such, each request centres on the diagnosis of specific patient’s condition and the identification of a suitable treatment and is essentially a problem solving (intellective) activity (WAP). Team members are typically sourced from a panel of experts maintained by MSF (PS) who may be remunerated for their contributions or may volunteer their time (PR). The specific

team members selected will depend on the characteristics of the individual case (SC) and, as such, this

group formation approach represents a form of co-sourcing that enables MSF to manage the varying

needs of each patient case and achieve an appropriate case outcome.

A request to assist with a case is directed to specific medical experts (AS,DM) through MSF’s

communication channels. Progress and content information relevant to a specific case is shared across

the same channels and is visible to all team members (WCS,SI) but its confidentiality is otherwise

maintained. Where a specific medical expert indicates they will assist with diagnosis and treatment

planning for a given case, they are individually responsible for its conduct in its entirety (WGD,WIC) and

the expectation is that they will deliver a quality solution rather than focussing on a quick fix (WAFO).

Individual cases are not further subdivided although additional experts may be invited to participate at

any time during their conduct (DT,WIA). Where multiple medical experts work on a given work activity,

they do so on an overlapping basis (WAS) at a time of their choosing (WGI) although overall progress is

tracked by the coordinator and some aspects of diagnosis and planning require the involvement of all

team members. The commencement and completion (CC,CC2) of activity on each case is determined by

the coordinator.

Reflections

The collaboration dimensions identified in this paper provide the basis for the establishment of a

comprehensive theory of collaborative work practice, particularly as it pertains to future work

environments. As discussed in the Introduction section, there is a broad body of evidence that suggests

the future workforce will be more fragmentated and distributed than it has historically been, with individual

participants operating more autonomously, working for a greater range of potential employers, and being

engaged on the basis of specific job requirements rather than in an ongoing employment relationship.

Furthermore, the body of available workers is likely to be more connected and accessible than ever before,

providing employers with the ability to access a far larger pool of more specifically qualified workers for

individual work activities that are able to be secured and marshalled on a more rapid basis. These factors,

together with the rise of collaborative work activities, motivate the investigation of the factors

that underpin collaborative work and enable its orchestration and conduct to be better understood.

The range of 21 distinct collaboration dimensions was derived through a broad literature review of the

past decade of leading business, management, human resource, psychology and information systems

journals. These dimensions have been positioned with the benefit of prior learnings from five widely

accepted IS theories. However, these theories exist independently of each other and only partially address

the notion of collaborative work practice as illustrated in Table 1. Given this gap in theory, we aim to

establish an integrated model of collaborative practice that identifies the broad range of factors that

characterise the alternative ways in which work activities, work participants and workgroups are able to

operate in such scenarios.

Having established key dimensions for collaborative work practice, we have validated the usefulness of

these dimensions by undertaking an initial high-level analysis of 22 real-life scenarios (of which three are

presented in this paper) and considering exactly how each scenario might be configured in terms of the set

of dimensions identified. This analysis is intended to provide an initial step in confirming that the various

dimensions provide an objective basis for describing a range of actual scenarios and that each of the

possible configuration dimensions are useful in practice.

Finally, in order to examine the depth of support for collaborative practice in current enactment

technologies, three representative offerings were selected across the technology spectrum for analysis

using the 21 dimensions. The resultant review of these offerings highlighted a number of gaps in the

extent of current collaboration support and provided insights into key areas and potential opportunities

for improvement.

Conclusion

The collaboration dimensions are grounded in the IS literature and guided by five well-founded IS

theoretical models. As such, they have the potential for use in a range of distinct contexts.
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Design of collaborative activities There is limited support amongst contemporary modelling formalisms and design methods for capturing the full configuration of collaborative activities in sufficient detail that they can be subsequently enacted without ambiguity. The various collaboration dimensions identify the broad range of factors that need to be considered as part of collaborative activity design and alternative configurations that may need to be catered for.

Operationalisation of collaborative activities Once the broad configuration of a collaborative activity is available, unambiguous enactment becomes feasible. Subsequent research needs to develop a comprehensive approach to executing a collaborative activity on the basis of a candidate configuration.

Design of collaborative environments Future work environments by necessity involves the recognition and integration of a range of parties in collaborative activities. The collaboration dimensions provide insights not only into work activities but also workgroup formation and work participant characteristics. These details can inform the design of the associated work contexts and entities that operate within them.

Extension of existing tools and formalisms As briefly indicated in Table 1, there is limited support amongst contemporary groupware tools for collaborative activities. These gaps in collaboration support give some initial insights for future developments in this area.

The overriding motivation for this work is that it will provide the impetus for establishing the theoretical foundation for a coordinative theory of collaboration. In their current form, the collaboration dimensions identify a range of constructs that are relevant to the description and conduct of multiparty, coordinative work activities and, as an aggregate, provide a framework that identifies the range of factors required to describe a specific collaboration scenario. Subsequent research work will focus on building an understanding of the specific configurations that are permissible for each of the dimensions and the level of detail that is required for a given collaboration scenario to be fully operationalised.

Acknowledgements

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