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Characterizing an Information Technology centric mechanism to Support coordination in a large scale distributed environment

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Abstract

Organizations constantly face challenges owing to limited resources. As such, to take advantage of new opportunities and to mitigate possible risks they look for new ways to cooperate and collaborate, by sharing knowledge and competencies. The segmented South African (SA) public sector is no different in that to ensure proper service delivery in the sector, various agencies must work together towards the attainment of common goals. Thus, coordination among partners is critical in order to achieve success.

However, this is not easy, the lack of coordination and its impact on current initiatives continuous to be a problem in the SA public sector given the complexity associated with the heterogeneous and distributed nature of the environment. Thus, the need to develop an Information System (IS) that is integrative and dynamic to accommodate the varying coordination needs across the distribute environment. This theoretical paper conceived from an extensive literature study, and a comparative analysis guided by case study analysis explores lessons from existing theories and technologies that focus on facilitating coordination towards defining a criteria for the design of an IS that can adequately support the coordination of cooperative work that exists in a large scale distributed environment.

Keywords: *Coordination; Cooperative Work; Distributed Environment; South Africa; Virtual Communities.*

1. Introduction

Cooperative work allows groups/organizations with limited resources to work together in support of each other goals or shared goal to combat the issues related to the scarcity of resources. This mutual reliance is generated as a result of cooperation, out of which negotiations and subsequent agreements emerge between the collaborators. Resource dependency theory posits that, for the survival of an organisation, it is crucial to close gaps regarding critical resources. As organizations have to constantly contend with a dynamic and unstable environment they cooperate by exchanging relevant information to facilitate collaboration, thus they can work together to take advantage of opportunities, solve problems or produce goods and services [1 2, 3], thereby creating interdependency. The establishment of networks, partnerships, alliances and inter-organisational teams to maximise limited resource utilisation has the potential to engender success [4, 5]; however this requires effective coordination among stakeholders to avoid conflicting or repetitive actions.

The South African public service is subject to the same issues as any organisation, in that correct and functional coordination among the various organisations charged with delivering public policy/services will prevent both redundancy and breaches in service delivery. This implies that ensuring practical, effective service delivery requires correctly coordinated activities from cooperating organisations or stakeholders.

Coordination of cooperative work in a distributed environment, however, can be a challenging and complicated endeavour especially when a workforce is physically dispersed, with participants unable to interact directly, making communication and the coordination of activities more difficult [6, 7]. For instance in the SA public sector coordination difficulty has been a recurring theme, as made evident in the NCBF 2008-2012, 2013-16 reports [8]. Essentially, while efforts have been undertaken to achieve problem-free coordination in the South African public sector, they have frequently been poor, insufficient or ineffective. The current approaches employed to support coordination are inadequate as they are predominantly manual, with sporadic, limited and ineffective IT-based interventions.

The challenges associated with the geographic dispersal of documents, their manual integration and limited

application support impacts on coordination, as there is restricted oversight pertaining to activities and resources. This results in, inter alia, conflict bookings and the overextension of staff. The issues associated with geographically dispersed documents, in consort with the difficulties in aggregating and sharing this information, impact on coordination, arising from the resultant occurrence of a great deal of duplication and incoherence. In addition, there are a number of possibilities and prospective elements which are hidden or missed, for instance potential opportunities to work together being concealed from various stakeholders with similar interests. This denotes that a flexible platform for creating and managing dynamic collaborative structures would be constructive, optimal and valuable.

Considering the need for flexible and adjustable structures, Mintzberg [9] Travica, [10] and Espinosa, et al., [11], advocate that information technology can facilitate flexible organisations, possibly consisting of multiple, dynamic project teams and decentralised networks of communication, among relatively autonomous groups (adhocracies). Essentially, the importance and significance of the requisite for viable, effective technological support, relative to coordination, cannot be overemphasised, especially if a workforce is physically dispersed.

As traditional coordination mechanisms continue to prove inadequate, particularly when collaborating members are not co-located, distributed workers resort to technology to provide them with the information and interactions necessary for decision-making and work coordination [6]. Consequently, as the dispersion and distance increases between core workers, so does their reliance on computer-mediated support to communicate and coordinate their actions. Shen, and Shaw, [12] Weigand, Van der Poll and de Moor, [13] assert that information technology can significantly reduce the costs of certain types of coordination. This paper argues the use of IT towards that end. Essentially, the paper investigates Information and Communication Technologies (ICTs) as suitable coordination support mechanisms to mitigate coordination breakdowns in a large scale distributed environment. A case example identifying coordination breakdown and subsequent resolution of capacity building interventions in the SA public sector is provided in section 3.

The next section review what coordination means in cooperative work and an examination of what coordination lessons may be extracted from both theory and practice. Thereafter, the paper explicates and envisions how the lessons learnt may be applicable to the South African public sector case study circumstance. Next, a discussion on the importance of adequately understanding the coordination need context, in conjunction with how ICTs can aid in mitigating coordination breakdowns in a distributed environment, for instance by leveraging the properties of virtual communities, ensues. Consequently, the discourse concludes accentuating the value of utilizing Information technology to facilitate and support coordination in the distributed South African public sector.

2. Coordination in Cooperative Work

Several authors have described and defined coordination [13, 14, 15, 16]; commonly indicating that, within cooperative work, there are multiple, diverse activities working towards a common goal, with interdependencies between these activities that must be managed. For instance, Malone and Crowston [14] define coordination as the act of managing interdependencies between activities performed towards achieving an objective. Cooperative work, therefore, denotes the management of interdependencies towards attaining a specific, common purpose, or objective. Accordingly, coordination is referred to as a process of articulating work and managing interdependencies to support and sustain collaborative efforts. However, to adequately negotiate agreements pertaining to the effective collaboration and coordination of activities, it is imperative to gain insight and awareness into the actions and accomplishments of all participants.

By Sharing information and resources members of a collaborative effort can accomplish their part in support of a mutual objective. According to Amir [17], while the decomposition of activities enable collaborating members to function autonomously, members still need to be aware of each other's' specific actions to coordinate and take cognizance of uncertainties that may occur to prevent incidents that may jeopardize the realization of a given collaborative objective [15]. This implies that several factors that may influence coordination outcomes must be taken into account. This factors are evidenced in articulation work which is referred to as the additional effort required for obtaining the actual collaboration from the sum of individual tasks [16, 18]. Thus, referring to the capabilities and resources toward that end. Activities of articulation work include among others the identification of the objectives of the collaborative group work; the mapping of these objectives into tasks; the selection of participants, in conjunction with the distribution of tasks among the participants; and the eventual coordination of the execution of the tasks.

In order to adequately account for the complexities of

coordination in a distributed environment, the subsequent sections explore and review lessons from existing theories and concepts. To identify the fundamental tenets and bases that will assist in the development of a suitable coordination solution in a distributed environment.

It is therefore the belief of the researcher that extracting and examining lessons from coordination-related literature and existing technologies may facilitate a better comprehension and articulation relative to how organisations can manage and resolve coordination breakdowns utilising ICTs in a large scale distributed environment. Thus, the characteristic of the solution is motivated from an extensive literature review of theory and practice as well as the qualitative environmental scan of the SA public sector as a case example. The next section highlights the methodology employed in this study towards a establishing a criteria for and IS design that can adequately account for coordination needs in a large scale distributed environment like the SA public sector.

3. Research Methodology

The research methods employed in this study to answer the query *"what should characterize an IS solution that can adequately support coordination of cooperative work in a large-scale distributed environment like the SA public sector?"* include a literature review, comparative analyses, a case study scan and argumentation. The core of the study is drawn from previous research, existing relevant technology architectures and through a case analysis of the distributed environment.

By conducting a systematic literature review the body of literature that concerns coordination in a distributed environment is unpacked to answer the question: *What are the known coordination constructs that can characterise and transform the coordination problem and solution space*. Fundamentally, the constructs relevant to understanding coordination breakdowns Coordination management constructs are identified and discussed making explicit the conditions and configurations which may limit or enhance coordination in a distributed environment. Through a comparative analysis [19] of coordination related theories and existing technologies in terms of their similarity and variance attention points come to the fore.

Lessons drawn from the literature and theories surrounding collaborative technologies are presented, especially in regard to strengths and weaknesses in practice. The correlation and combination of proven theories and existing technologies, with specific focus on facilitating coordination, allows the achievement of a unique combination; thereby facilitating and producing a novel approach to the research problem.

The synthesis of the literature, through informed arguments, provides the foundation from which the IS criteria are established. Lapakko [20] and Walton [21] define argumentation as an inductive process based on research strategy, which directs the construction of convincing conclusions, founded on assertions arising from reasoned discourse.

To gain an in-depth understanding of the application domain, however, a qualitative approach [22] was engaged, utilising a single case study [23] as can be seen in Thomas et al., [24] in order to understand the complexity of coordination within the environment. As a strategy, a case study supports a comprehensive evaluation of real life occurrences within a specific context, which may reveal hidden evidence [23, 16]. The requirement for the case study research strategy results from the complexity of the phenomenon under investigation, as it cannot be comprehended or viewed in isolation from its environment [18]. Customarily, findings from case studies are useful in generating hypotheses from which generalisations for providing solutions to similar circumstances may be inferred [25, 23]. To effect useful theories the strategy involves choosing a representative sample of the situation under investigation. The selected case should have a significant resemblance to the particular population, family or institution to which it belongs. In this study the South African public sector exemplifies the distributed environment intended for examination. An overview of the case of interest that characterise the large scale distributed environment is provided in the next section.

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4. The South African Public Sector Case Study

Drawing from the environment, with specific focus on the capacity building training intervention process targeted at municipalities within the SA public sector, a coordination problem is identified. South Africa has a complex governmental structure, involving a number of provinces, local governments and municipalities with different authorities and responsibilities [8].The Republic of South Africa is divided into nine provinces, currently comprising 226 local municipalities. These municipalities employ approximately 230 000 personnel, distributed across 2 798 kilometres. The dispersed staff participate in capacity building and training initiatives provided by various national, provincial, municipal departments and associated institutions, undertaken in an effort to ensure effective service delivery in the sector. Figure 3 provides an overview of the relevant players. To coordinate their activities successfully, these participants are required to be

aware of the actions of each other; which engenders the importance of the consideration of the nature of their relationship, in consort with how it is regulated.

The three spheres of Government (National, Provincial and Local) are distinct, but also interdependent, as they work together towards a common governmental goal. All areas of government are required to observe the principles of cooperative government, as mandated in Chapter Three of the Constitution including the coordination of activities to avoid duplication and waste [26].

The complexity associated with the distributed, disseminated nature of the environment, heterogeneity, autonomy and the increasing need to collaborate, engenders the need to develop a novel coordination support system for the South African public sector.

It is evident that the South African public sector exhibits the complexity associated with distributed coordination, which factors include: *inter alia,* size, the governmental structures, the number of role players, and its loosely-coupled work pattern. The magnitude of the complexity imposes a crucial need to develop a coordination support mechanism which encompasses the dynamic collaborative needs of the public sector. In effort to realize such intervention the next sections look to highlight lessons from coordination related theories and practice towards establishing an IS design criteria for coordination support in a heterogeneous and distributed environment. The next section starts off with lessons courtesy of the coordination related theories.

5. Coordination Lessons in Theory

Coordination theory provides a generalised representation, which may be used to capture and re-design a wide array of processes or business processes [25]. The coordination theory contends that alternative processes can be defined through the identification of the dependencies within a given process, in consort with considering which alternative coordination mechanisms may be employed. This denotes that a useful initiation point for process analysis and redesign is to search for or identify dependencies and coordination mechanisms. Additionally, Malone and Crowston [14] observe that coordination mechanisms also rely on other necessary group functions. This infers that developing a complete model of a specific process may involve the modelling of all of the aspects of, *inter-alia,* coordination, communication and decision making.

Multiple authors, including Mintzberg [9], Marlone and Cawston [14], as well as Sposito [27], submit that it is necessary to observe the issue from the perspective of manifold dimensions to fully comprehend the complexity of the modern organisation. Espinosa et al., [11] avers that *context, task, and team* variables can influence the potential types of dependencies encountered, and consequently, the choice of coordination mechanisms that could be employed to manage the dependencies. To appraise coordination possibilities from diverse perspectives, previous work generated from an assortment of disciplines is examined, in order to gain insight into, and an understanding of, possible coordination breakdowns, together with how to resolve them. The theories and concepts taken into consideration and studied include: Coordination Theory [12, 14]; Open System Theory [28], [29]; Activity Theory [30] the Service System Suites [31]; and PSI Theory [32].The resulting coordination management constructs which can be used to characterise coordination are depicted in Figure 1, termed the Catalogue of Coordination Constructs**.** The construct leverages the concept of interdependency and coordination mechanisms.

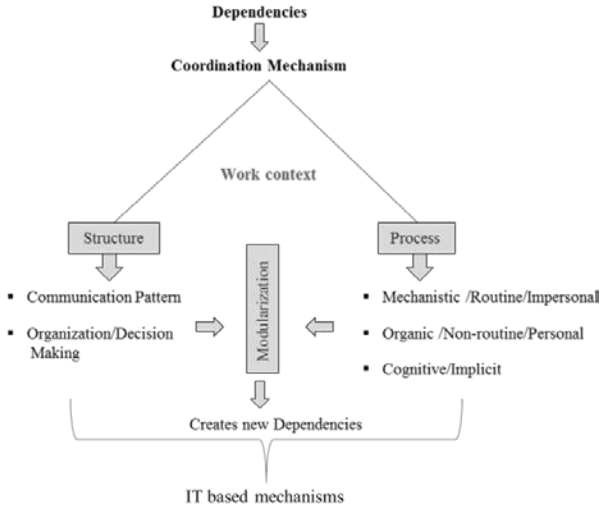

Fig.1 Catalogue of Coordination Constructs. Adapted from Thomas and Botha [33]

Figure 1 presents coordination mechanisms as comprising two aspects, viz. structure and process, defined to manage interdependences. The coordination structure provides the necessary connections required to execute the process. The coordination process may be regarded as building the structure, through facilitating communication and configuring decision-making patterns. In addition, it complements modular-based structures by, for example, optimally prioritising or rearranging modules. Therefore, the relationship between the mechanisms is reciprocal, as they usually co-exist in an organisational setting. All which are deemed manageable by IT [34, 26]. The IT-based mechanisms can support coordination by capturing,

processing, storing, and exchanging information through services, comprising: electronic calendaring/scheduling; shared databases; and groupware [32], 24, [34). Weigand et al., [13] postulate that, aside from enabling both synchronous and asynchronous communication, ICT can reduce the degree of information asymmetry and uncertainty by disclosing relevant information on time, with clarity, to the pertinent actors. The employment of technology as an alternative to other coordination mechanisms, or to simply augment/enhance them is regarded as constructive, beneficial or valuable. The perception and categorisation of IT within the theories and concepts is summarised in Table 1. Espinosa et al., [11] contend that, taking into account the evolutionary nature of organisations, in consort with the coordination mechanisms employed, these entities should be enabled by information and communications technology (lCT) systems. Thus, the lesson from table 1 suggests that ICT functionality should facilitate adhocracies by creating and managing dynamic collaborative processes and structures in an agile and adaptive environment that transcends distance and space. Other lessons associated with the constructs in figure 1 including the analysis focus dimension can be seen in table 2. Further details on the origin of the lessons can be found in [35]. The subsequent section reviews how coordination is conceived in practice.

Table 1: Perception of IT-Based Mechanisms from theories and concepts

IT-based Mechanism				
COORDI-NATION THEORY	*OPEN SYSTEM THEORY*	*ACTIVITY THEORY*	*SERVICE SYSTEM SUITE*	*PSI THEORY*
Support information processing to reduce coordination cost	*Support for process Efficiency, Intersystem interaction, Support for modular service abstraction and integra-tion, System Sustainability and adaptive evolution*	*Means of work , mediation (communi-cation & coordination) and networking Facilitates adaptive operational evolution*	*Support for process activities and service/self-service interaction Modular abstractions of services /interfaces standardisation for business process flexibility and interoperability Sustainability and adaptive evolution*	*Support for communication acts. Information process and knowledge management for process support.*

Table 2: Summary of lessons from coordination theories and concepts

**LESSON LEARNT denoted as "L*"*
1. Analytical Focus (understanding the coordination problem context)
*L1 * the analytical focus should encapsulate the micro- and macro-context which accounts for a collaborative activity that captures a cooperative business process and its host environment which consists of influencing factors that can affect coordination.*
COORDINATION CONSTRUCTS
2. Interdependency
*L2 * Interdependency represents the nature and degree of coupling between interdependent organisations and their constituents engaged in collaborative acts which can determine the suitability of the coordination mechanisms employed.*
PROCESS-BASED MECHANISMS
3.Mechanistic Mechanisms
*L3*Ensuring and instituting an agreed set of protocols and standards can facilitate interoperability, common understanding and guide the actions and behaviours of multiple role players towards achieving a common objective with minimal overheads.*

LESSON LEARNT denoted as "L"*
4.Organic Mechanisms *L4* In this study it reflects a mechanism that facilitates the adaptive synchronisation of action between collaborating entities from the initiation of projects to their conclusion especially in situations of uncertainty, while taking account of changes that may occur, in order to adapt accordingly and stay on track.*
5. Cognitive/ implicit *L5* Having a shared insight, founded on common understanding, can enable collaborating members to gauge member circumstances, anticipate the actions of collaborating members and act or react appropriately towards accomplishing a cooperative work objective, in a non-intrusive way, while accounting for and accommodating changes in the dynamic environment.*
STRUCTURE-BASED MECHANISM
6.Communication pattern *L6*The communication pattern represents the collaborators' shared communication model that results over a period of time, which may employ both formal and informal communication approaches to manage and facilitate timeous information diffusion and reactions to suit the dynamics of a specific context.*
7.Organisation/Decision-making structure *L7* Reflects the characterisation of the management process and governance structures employed by collaborating organisations to manage their relationships and achieve a sense of coherence, increasing efficiency by controlling the flow of information, while ensuring accountability.*
8. Modularisation *L8*Reflects the division of complex task into manageable parts or concerns to be addressed or function separately, but can be dynamically assembled to work together as a whole to achieve uniquely defined objectives.*
9. IT based mechanism *L9* Reflects the dynamic integration of ICT functionality that facilitates adhocracies by creating and managing dynamic collaborative processes and structures in an agile and adaptive environment that transcends distance and space.*

6. Coordination Lessons in practice

The subject and theoretical construct of the multidisciplinary research field of Computer Supported Cooperative Work (CSCW) has been the support for cooperative work. In this investigatory field, coordination practices are considered from a sociotechnical perspective, taking into account the people who collaborate and the processes through which they do so, with the tools and technologies that support their efforts [36]. How existing tools and technologies have supported coordination efforts is the focus in this section.

Computerised support for collaboration has been recognised as necessary and indispensable when the collaborating users are physically distributed. The propagation of personal computers and their corresponding networks has made the electronic support of geographically distributed groups feasible, cost-effective and realistic. This scenario has become more common, with the advances in networking technologies and the increasing popularity of the Internet and the World Wide Web. Holt [37] advocates that coordination technologies should, in a flexible and well-integrated manner, express tasks, their diverse relationships and connexions to each other, as well as the people responsible for them, while accounting for unpredictability. Although there is no consensus on classification schemes relative to these technologies, the degree of human participation in the coordination process and the level of task automation are currently utilised. The scope of support spans from fully automated coordination decision support systems, to those which simply facilitate human interaction through communication, in order that coordination is realised. To provide a foundation for the development of an artefact which can support coordination effectively in distributed environments, we explore certain technological fields, encompassing cooperative groupware; workflow management; and virtual communities. Figure 2 portrays the collaborative tools, relative to their level of support for task-automation and process structure, on a grid adapted from [38].

Fig 2. The Collaborative Tools Grid. Adapted from Dustdar and Gall [38]

Table 3 presents a summary of the properties of collaboration tools, reflecting their similarities and differences. While cooperative groupware tends to support more unpredictable and ad-hoc interaction groups, workflow extends automatic strategies and provides predefined procedures to guide individualised tasks. Virtual communities are frequently central, although closer to extremes in certain instances, with the capability of leveraging both worlds as the situation presents itself, while accounting for a large number of people. Despite this, their overall objective remains constant and consistent, viz. to increase the combined effectiveness of groups or teams engaged in the achievement of a mutual; or common objective [38]. In order to afford effective support towards the coordination of distributed teams, dynamic and emergent processes must be supported. Fundamentally, process models have to be more flexible than traditional workflow control-flow oriented models, in consort with pursuing process awareness. Knowledge, including instructions, experience, and reasons for decisions among others, is often required by workflow participants to implement activities during process execution [39] and therefore, must be provided for.

Tellioglu [40] maintains that achieving sustainable collaboration requires a methodological framework, in conjunction with a coordinated work environment that is configurable, offering users interfaces to integrate with other tools to support collaboration. This study contends that engaging a virtual community perspective from a service lens, while leveraging context awareness could assist in the achievement thereof.

Gross and Koch [36] avers that work groups operate in larger organisational contexts, with the structure and culture of an organisation influencing the way a groupware system should be designed and will be used. The authors maintain that, for a groupware application to be accepted and used, the social and organisational characteristics of a group must be considered to prevent the rejection of the design by the users. Pinelle and Gutwin [41] asserts that designers must consider complex social and organisational issues when designing groupware applications. Marty [42] contends that the inability to address any balance disparities can result in inefficient work practices. Cooperative systems have been defined as a combination of technology, people and organisations, which facilitate the communication and coordination necessary for a group to work together effectively in the quest of a shared objective, to achieve benefits and advantages for all its members [43].

Table 3: Summary of Collaborative Tools Properties

PROCESS	*MEMBER AWARENESS LEVEL*	*INTERAC-TION*	*DOCUMENTATION/ TRACKING*
COOPERATIVE GROUPWARE *(Formal teams/group formation of known members)*			
Unstructured/unpredictable *assumes dynamically shifting goals*	*Group awareness of past/present co-workers*	*Synchronous/ asynchronous ad-hoc Formal/informal communication/ shared work space*	*No- obvious structure* *Difficult to keep track of activities + interactions*
WFMS *(Individual functions in departments – Organisational)*			
Mostly Predictable (highly structured-semi-structured formal model) *Assumes well-defined business goals*	*Individual activity awareness* *Organisation process model specific*	*Formal (work list)* *Asynchronous communication*	*Easy documentation and tracking made*
VIRTUAL COMMUNITIES *(Dynamic teams/groups formation in larger community of known/unknown members)*			
Dynamic degrees of semi-structured to unstructured *Somewhat-defined +dynamically shifting goals*	*Ad-hoc /informal community/group/* *individual* *activity level and* *real-time action running commentary and presence*	*Social protocols* *Synchronous/* *asynchronous ad-hoc formal/informal communication* *Shared work space*	*Fairly balanced easy documentation/tracking*

Thus, the socio-technical components that must be in equilibrium are the people who collaborate, their supporting processes, and the tools responsible for the transformation of an organisation, as such they remain the

coordination support pillars of an organization. Lessons on The Effects of Collaborative Technologies on Coordination Support Pillars is summed in table 4. Details of lessons origin can be found in Thomas [35]. By taking into consideration the lessons encountered from the foregoing theory and practice, the subsequent section attempts to comprehend, and ultimately address, the coordination concerns within the distributed SA public sector.

Essentially, this can change the SA coordination 'As-Is' (problem context) situation to the envisioned 'To-Be' (Solution context) status, as illustrated in Figures 4 and 5, respectively and as made explicit in the subsequent sections. The succeeding section contributes the context towards a solution model, by previewing the expectations in practice, through a review of the practical 'As-Is' situation in Section 7.1 to an envisaged 'To-Be' in Section 7.2.

Table 4: Summary of Lessons extract on collaborative technologies influence on coordination support pillars.

CATEGORY	*LESSONS*
PEOPLE	
1.1 Social Cognition *frames and mental models: language, culture, beliefs and norms*	*L10*Shared social cognition means availing social and working context awareness to members of a collaborative community with similar interests, shared language and beliefs to leverage hidden opportunities.*
1.2 Knowledge of Working relationship *Stakeholders involved: Who and what they are doing.*	*L11*Working relationships accounts for knowledge that helps manage expectations and predict actions of role players automatically to support implicit coordination.*
1.3Communication *Sporadic face to face* *Telecommunication Voice/fax technology*	*L12*Represents support for varied communication channels that can adapt to the need context of users, helping to avoid misunderstandings and mismatches between collaborator*
1.4 Information and knowledge *Physical social interaction* *Post mail/travel, localised information/knowledge management systems*	*L13*Information and knowledge awareness constitutes taking advantage of context information and communication channels to effectively distribute relevant information and knowledge to members, in order to facilitate collaboration and coordination of their actions.*
1.4 Organisational structure *Direct contacts/supervision, committee, hierarchy/liaison devices* *Highly structured 'heads-down' paper processing*	*L14*An organisational structure defines support for ad hoc and dynamic team formation, whether employing centralised or decentralised forms of management to support dynamic collaborative efforts.*
PROCESS	
Work-practice mechanisms *Plans, specifications, standards, manuals, instructions* *Paper based transactions* *Highly structured "heads-down" paper processing*	*L15*This means support for the seamless transition between process types to account for varying engagement scenarios from automation across processes to support for dynamic human intervention through the use of dynamic templates and tools as required by the collaboration context from its initiation to completion.*
TOOLS	
Paper based artefact, *Post-it note, letter, telephone*	*L16* this reflects the use of approaches that allows dynamic, seamless and loosely coupled integration of the functionalities of varying tools to support collaborative processes that can span across organisational boundaries.*

7. A Functional Example from a Case Study

The lesson learnt in the previous section suggest that since there is no size that fits all solution it is imperative to understand the coordination context the environment offers before prescribing a solution. Based on the lessons learnt in the previous sections, a functional example of the SA case study that encapsulates the status quo and an envisaged solution given in terms of the lessons learnt from the coordination theories and practices and practice is presented in the next section.

7.1 The 'As-Is' Situation

A preliminary view of the status quo of the extant capacity building situation is provided in Figures 3 and 4, which overviews the problems encountered. Figure 3 shows the number of the primary role players engaged in the capacity building efforts in the sector and the reporting/communication structure.

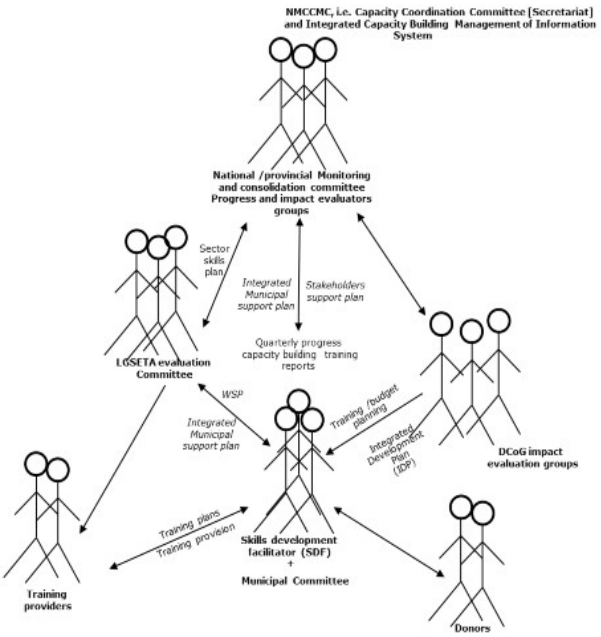

Fig. 3 Collaborating Actors' Relationships and Information flow complexity

The predominant problem evident involves the consolidation of documents, demonstrated in the representation of the document flow. Basically, the coordination problem spans three phases in the capacity building process, viz. the Requirement Elicitation, Tactical, and Evaluation stages as shown in figure 4. Thus, it features organization, information sharing, people, process and tools problem. The problem points are presented figure 4 in red heptagons, with the interpretations supplied in Table 5.

Table 5: Some Case Based Coordination Problems

PROBLEM LABEL	PROBLEM DESCRIPTION
P1	Multiple duplicated planning documentation
P2	Multiple, dynamic and distribute work groups
P3	Isolated offers
P4	Wasted collaborative opportunity
P5	Duplication of training
	interventions
P6	Information timing
P7	Manual integration

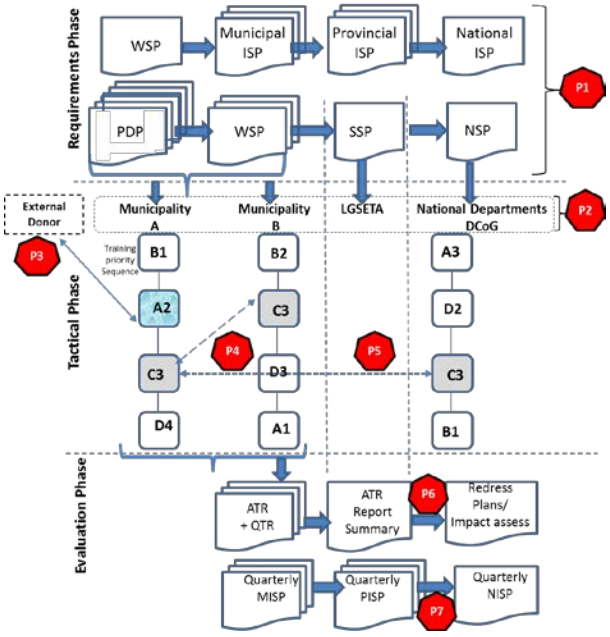

Fig. 4 A Preliminary Coordination Status-Quo

As illustrated in Figure 4, the **Requirement Elicitation Phase** consists of numerous documents, located in several different places, aimed at a common purpose. This phase engages many manual approaches, making coordination a difficult task. For instance, as shown in Figure 4, plans as separate entities are derived from others, but not from the same document nor in the same place. These are periodically accessed and compiled by human workers to aid coordination. As indicated, multiple Personnel Development Plans (PDPs) feed into a Work Skills Plan (WSP); many WSPs form the Sector Skills Plan (SSP)/Municipal Integrated Support Plan (MISP), which in turn feeds into the National Skills Plan (NSP)/National Integrated Support Plan (NISP) through the Provincial Integrated Support Plan (PISP) etc. The overwhelming inconvenience, complexity and burden that the situation presents must be addressed. The challenges associated with the geographic dispersal of documents, their manual integration and the limited application support, impact on coordination, as there is limited oversight and communication regarding activities and resources. This results in conflict bookings and the overextension of staff, as well as numerous other issues.

In the **Tactical Phase,** the lack of insight into the on-going intervention activities of peer municipalities and national bodies results in wasted collaboration opportunities and the duplication of interventions. This is shown in the replication of the C3 training interventions activity in Figure 4, which occurs in all agencies. Moreover, some of these interventions may not be reflected in the plans and may only occur because a third party player, for instance an external donor, sponsors a certain intervention. Therefore an event, for example A2, may be completely hidden. This illustrates that such isolated offers make it difficult to plan and to coordinate efforts.

The **Evaluation Phase**, similar to the planning phase, consists of numerous distributed reports (e.g. Annual/Quarterly Training Report (ATR's/QTR's)), generated and distributed across several paths. This phase is overwhelmed with distribution and integration challenges, which consequently affect progress and impact on assessment timing. This negatively affects the redress intervention effort. Additionally, quality control and success measures relating to coordination are hindered and made more difficult. Besides the inconvenience and obstacles in accessing information, in consort with the existence of multiple versions of the same information, other issues include the use of obsolete or inaccurate information; inconsistent coding; the misinterpretation of information; and the manual re-entry of information.

Accordingly, a fundamental function of the proposed solution is to provide management and awareness information services to collaborators, as elaborated in the ensuing section.

7.2 The 'To-Be' Situation

Figure 4, this section provides an envisaged virtual community-based solution premised on the promise virtual communities hold as potential coordination mediating artifact, as depicted in Figure 5. The solution advocates a system that provides an integrative, immediate and continuous access to information relating to the activities of others, focusing, *inter alia*, on information integration and an on-going, continuous awareness of all activities. It is significant to observe the principal difference between the figures. In Figure 5 the implementation results in a system from which documents can be produced. Figure 5 reveals that the support for requirement elicitation, planning, execution and evaluation are all initiated within, and arise from, the system. In this solution, different aspects of the same information may be provided, as portrayed in the **Requirements Phase** of Figure 5. The information physically distributed in Figure 4, at the requirements phase, is consolidated in Figure 5.

This is conceptually positioned in a distinct location and monitored, with the potential for generating documents or views from the single information source. The requirements phase depicts how the information from several documents may be contained in a single view, possibly from multiple information sources. The red coded bar represents the context driven requirement elicitation, while the cyan colour corresponds to continuous monitoring. This indicates having insight into several problem contexts, through which collaborative opportunity identification is made possible, by continually monitoring and documenting environmental needs. This level of awareness is integral to the initiation of the collaboration life-cycle model in the tactical phase. The virtual community infrastructure, portrayed in Figure 5 promises to help match user interest requirements to the offerings made by publishers, as well as monitoring and tracking actions as they occur.

The **Tactical Phase** signifies the identification of multiple occurrences of similarly planned activities, aimed towards collaboration, exclusion or transfer in order to mitigate duplication and reduce or eliminate waste. While the agencies conduct their individual tasks, the system should provide them with information as required. Within the tactical phase, multiple conversations occur inside the system to keep stakeholders informed of on-going activities.

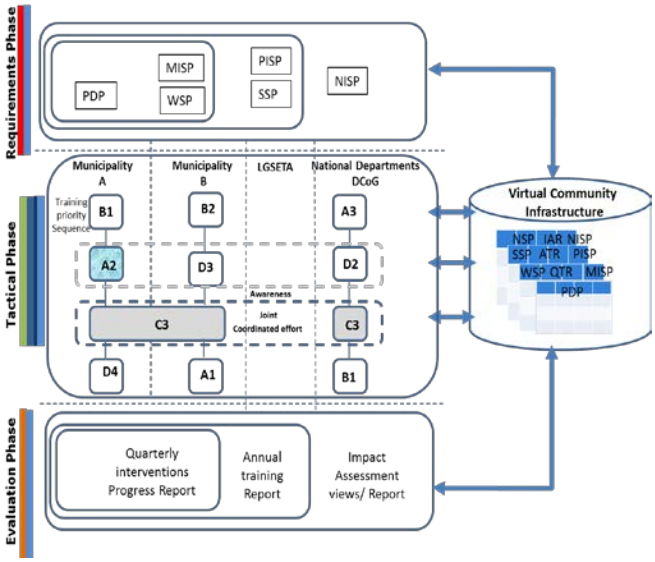

Fig. 5 Coordination 'To-be'

The possibility of one intervention taking place among the three agencies is represented by the broken lines in Figure 5, within the execution phase. Two C3 activities exist within a dotted line, indicating that, although there might still be more than one occurrence of C3, it will not be for the same municipalities. At this point two municipalities may still work together, but the intervention from the national body may be offered to another municipality. The larger C3 box indicates that two municipalities may choose to work together, depending on their proximity, taking advantage of a collaborative opportunity. The smaller C3 box represents the national department, which after gaining insight into the existing interventions occurring within the municipalities, as a result of collaborative efforts between them or donors, may choose to join efforts or instead, to re-channel their interventions to alternate, less fortunate municipalities, which may require them more. The colour coding in the tactical phase represents the necessity to define certain elements, viz. the working objectives (green); planning and design (blue); control implementation (dark-blue); and monitoring for deviation (cyan). The **Evaluation Phase**, with the orange colour coded bar, focuses on the timeous and effective assessment of progress and impact, to ensure or facilitate appropriate and timely intervention. The evaluation may also be conducted by utilising a single information source, with the capability of generating multiple reports as the situation presents, while monitoring quality and success rates.

The criteria towards the design of a suitable IT artifact to support coordination in a large scale distributed environment like the SA public sector is presented in the next section.

8. The Desirable design Characteristics for an IT artefact to support coordination in a large scale distributed environment

Considering the distributed nature of the environment, as well as the number of decentralised and dispersed players, a context-sensitive infrastructure, which is open - thus, extensible, scalable and reconfigurable - is emphasised, to meet the dynamic coordination needs. Essentially, given the sociotechnical need that the solution must satisfy as indicated in lessons L3 through to L16 in tables 2 and 4 what this signifies is that two aspects, viz. a static and a dynamic component must be addressed. The static component represents a supporting environment, required in place for coordination related operations which is dynamic to be carried out. The dynamic element denotes the support process of how things occur, as per the means of work, for which a process model can be devised. The benefits of having an operation support model and a leveraging environment that is flexible, scalable and configurable to support collaboration, as emphasised in Section 3.2, is desirable to assist in streamlining coordination in a distributed environment. Lesson L9 in Table 2 accentuates the requisite for an IT based model as integral to the solution. Thus, a virtual community centric approach is advocated to account for the technical environment and the dynamic model the operations or behaviour. The desirable design characteristics echo virtual community properties as noted section 2. Figure 5 showcases a summary of the properties that must be exuded by a supporting solution to adequately streamline collaborating member activities.

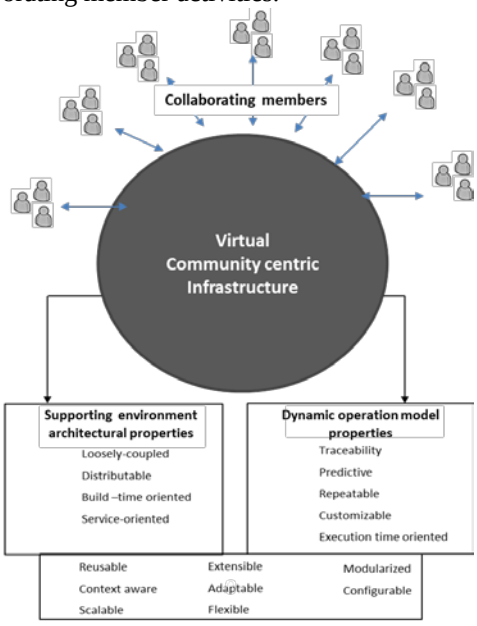

Fig.5 Desirable design characteristics

Essentially virtual communities provide a suitable base for the model development as they represent self-organising socio-technical systems that exhibit dynamic properties such as flexibility, adaptability, scalability and robustness among other things. Thus, they are accommodative to new opportunities to collaborate and manage uncertainties.

Relative to the supporting environment by leveraging the potential benefits of Virtual Communities, a flexible, context sensitive middleware infrastructure, capable of coping with the needs of diverse collaborative scenarios, is stressed. Its *flexibility* reflects the capability of the envisioned system to adapt rapidly to any of a variety of emerging and evolving behaviours in collaborative organisations; signifying that the proposed solution must be open with regard to the integration of technologies and tools, as it must account for existing tools and

concurrently, be extensible, in order to accommodate new solution models with minimal difficulty. This is accentuated in lessons L2 and LI6 of Tables 2.11 and 3.8, respectively. To encompass the complexity associated with coordination in a distributed environment, a loosely coupled approach emphasized, taking into account the separation of concerns through modularisation as established in lesson L8 table 3.

The principle of loose coupling makes applications more flexible, more easily adaptable, with greater responsiveness to changes. Modularisation as a design pattern reduces the complexity of the system by subdividing the complex whole into smaller parts (modules or components), which can be created independently, and can then be utilised in different systems to drive multiple functionalities through well-defined communication interfaces. By applying the principles of composability and loose-coupling it is ensured that the design can be *configurable* or re-configurable (to meet varying needs), denoting that it can be highly adaptive and extensible. Components should be designed to be reused in different scenarios with diverse applications. These elements should be capable of being readily substituted for other similar components, thus replaceable and extensible from existing components, in order to provide new behaviours.

Furthermore, the envisioned support infrastructure must be distributable, providing standard procedures or processes for invoking functionality remotely across different platforms, used by several people in different locations. This is supported by lesson L16. It must be scalable, to accommodate growth. It must possess the capabilities and capacities to cope and perform at an increased or expanding participation level or in cases of larger operational demand and, in addition, must be context sensitive. Context-awareness is imperative in a situation where the operating environment is constantly changing. In order to recognise, react rapidly and cope with the unpredictable changes in the environment, the envisioned infrastructure must account for context. This is highlighted in lessons L4, 10 and 13. Context, principally, refers to all types of information pertaining to a service and/or to the user of the service. The proposed model must take advantage of context information to provide services that will aid in the coordination of collaborative activities, from recommendation to the execution and monitoring of tasks.

A consequence of the dynamic approach, which is process driven, and its sustainability, is that it must be repeatable, measurable, flexible, reliable, predictive, and modular, with clear inputs and output, customisable, configurable, and adaptable to changing operation contexts, environments or system characteristics. More so, support dynamic integration and the reuse of processes and tools. The model must account for proactive and reactive properties to predict occurrences and respond appropriately when uncertainties arise. Thus, behaviour is adjusted relative to the perception of the environment and continuous improvement. These are highlighted in lessons L5, L6, L7, L9, and L14-16 portrayed in Tables 2 and 3, respectively. Other properties include goal orientation, to align design and configuration and to provide traceable planning, implementation and evaluation; and traceability, which links related artefacts and provides insight to resources and actions as can be learnt in workflow management. In addition, scalability as advocated by virtual community properties, to accommodate various situations and allow configurability to be customised to the needs of collaborative projects.

9. Discussion and Conclusion

It has been established that collaboration support technologies present a complementary approach to coordinate work, in conjunction with the explicit division of labour, for example within a distributed environment. Once a cooperative need context is understood and appropriate coordination mechanisms and tools are put in place successful realization of objectives becomes possible.

Since IT has been established as crucial to the support of coordination, especially in a distributed environment, this study centered on defining a set of characteristics for the design of an IT artifact geared towards streamlining and promoting sustainable coordination in a large scale distributed environment like the SA public sector. The relationship and combination of proven theories and existing technologies, with specific focus on facilitating coordination, allows the achievement of a unique combination towards establishing the desired design characteristics. Thus, both a static supporting environment and operational behaviour characteristics are emphasized.

Besides that, to inform the design of a suitable IT artefact for coordination support in a distributed environment the research explored coordination constructs that characterize and transform the problem and solution spaces. Therefore, identifying coordination breakdowns before their resolution in the form of an ‘As-Is’ to a’ To-Be’ models are acknowledged, and explained.

The suggestions from theory and practice and the unique environmental conditions identified advocates taking a socio-technical approach to adequately account for the coordination requirement in a distributed environment. Since almost every situation provides its unique coordination complexities, with dependencies which are very domain-specific, business analysts or enterprise architects must adequately understand the environment to

consider the suitability and practicality of the coordination mechanisms within the need context. This implies that the unique characteristics of a specific context must be accounted for, as there is no single solution applicable to all. However, it is the belief in this research that a virtual communities can provide a sound base for the design of an e-infrastructure capable of supporting coordination in a distributed environment like the SA public sector. This denotes that a socio-technical perspective, focused on the interdependencies between and among people, technology, and the environment, towards a self-regulating system capable of meeting environmental demands, is necessary. Concurrently, it must be resilient to external disturbances and responsive to change. Thus, a technical infrastructure in the form of a virtual community that hosts individuals with a common interest and guides their realization of that interest while taking cognisance of environmental changes or uncertainty is desirable.

Essentially virtual communities should be leveraged as a suitable foundation for coordination support in a large scale distributed environment, as they represent self-organizing socio-technical systems, exhibiting dynamic properties, encompassing, inter alia, flexibility; adaptability; scalability, and robustness, capable of coping with the needs of diverse collaborative scenarios. Its flexibility reflects the capability of the envisioned system to rapidly adapt to any of a variety of emerging and evolving behaviours in collaborative organisations; signifying that the proposed solution must be open with regard to the integration of technologies and tools, as it must account for existing tools and concurrently, be extensible, in order to accommodate new solution models with minimal difficulty Thus, future work should explore the appropriateness of a virtual community-centric solution to adequately account for the coordination requisites of the SA public sector through actual implementation. More so, develop a comprehensive tool to support business analyst or enterprise architects in eliciting and projecting coordination support requirement of any given distributed context

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