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TEAM OF TEAMS AS DISTRIBUTED COGNITIVE SYSTEM: REFLECTION THROUGH DICOT

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Tässä tutkielmassa tutkitaan kirjallisuuskatsauksen keinoin käsitteitä hajautettu kognitio ja team of teams. Hajautettu kognitio perustuu ideaan, jossa kognitio ei tapahdu vain yksilön mielessä, vaan hajautuu sosiaalisissa interaktioissa, artefaktien avulla ja ajallisesti. Team of teams on ytimeltään tiimipohjainen, voimakkaasti hajautettuun päätöksentekoon ja yhteyksiin perustuva organisaatiomalli. Kuten tutkimus osoittaa, kumpikin käsite on laajentunut koskettamaan useita konteksteja viime vuosina. Kumpikin käsite on myös muuttunut koherentimmaksi erilaisten mallien ja viitekehysten muodossa. Kuitenkin laajempien organisaatiomallien ja hajautetun kognition yhdistäminen on ollut kirjallisuudessa vähäistä. Tämä tutkielma tuo lisää sisältöä kyseiseen kontekstiin reflektoimalla erityisesti Yhdysvaltojen armeijan Task Force:n käyttämää Team of Teams (Kuvio 2) organisaatiomallia hajautetun kognition näkökulmasta, käyttäen DiCoT-viitekehystä (Kuvio 4).

Asiasanat: Hajautettu kognitio, team of teams, DiCoT, Distributed Cognition for Teamwork

ABSTRACT

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In this thesis a literature review is conducted on the concepts of distributed cognition and team of teams. Distributed cognition is based on the idea that instead of cognitive functions happening only in the minds of individuals, it is distributed with social interactions, artefacts, and time. Teams of teams in its core is a team-based, highly decentralized and interconnected organizational model. As the research shows, both concepts have had large variety of different context they have been implemented in recent years. Both concepts have also had a trend of coherence through different models and frameworks. However, combining larger organization models and distributed cognition has been rare in the literature. This thesis offers contribution to the existing literature by reflecting the case example of US Task Forces organization model in Iraq, the Team of Teams (Fig 2.), through a specific framework of distributed cognition: Distributed Cognition for Teamwork (DiCoT, Fig.4).

Keywords: Distributed cognition, team of teams, Distributed Cognition for Teamwork, DiCoT

KUVIOT

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TABLE OF CONTENTS

1 INTRODUCTION

We live in a world with ever increasing speed of change, dynamism, and complexity. This can be said to be due to technological advancement, that has enabled us to communicate with extreme speeds and a global reach. As the technological advancements have increased our capabilities in communication, it has also increased the speed of information diffusion. This, coupled with the disturbingly fast speed in the ability to act and create, has brought organizations into an environment that can be, in the least, described as complex and even chaotic (McCrystal, 2015; Fussell, 2017; Kurtz & Snowden, 2003; Vasconcelos & Ramirez, 2011; Grant, 2003; van Fenema, 2004, p.134).

1.1 Increasing complexity

As one tweet can cut 14 billion dollars from a company's value (Hotten, 2020) and one man's suicide can trigger a revolution (Blaise, 2017), how can one forecast what happens next year, when one cannot know what the most powerful man on earth does the next day? (Kilgore, 2016). Increasing complexity is especially relevant issue for contemporary organizations (IBM, 2010, p.15). As seen in the recent decades, even the previously unopposed giants of companies have faltered and failed to evolve into the new environment, giving way to fast growth companies that thrive often on the speed of change. This can be seen for example in the reducing corporate lifespan in the S&P 500 (Scott et al., 2018). Many companies and organizations, that have not been especially *grown* into this environment, have the challenge of changing and accommodating into this new world. A successful example, explained by Steiber and Alänge (2013), is the formation and nurturing of Google and its corporate culture.

There has been an evolution of different organizational structures, as the environment they act in has changed. These include division structures, matrix structures and faster models such as adhocracies and team-based organizations (Grant, 2018, p.148-150). This has happened also on the front of manufacturing

and other process-related models, relating to the need to respond to the ever-faster environment and ever hardening competition, often described as hyper-competition (D'Aveni, 1998). There is also the increased need for innovations to keep companies afloat – let alone thrive and succeed in beating others. Agile (ITNOW, 2013), TQM (Hinge, 2016), Kaizen (Dyer, 2016), Six Sigma (Barjaktarovic & Jecmenica, 2011) etc. have brought new tools to different companies to be more efficient, responsive and acting faster. The Cynefin model in Figure 1 (Kurtz & Snowden, 2003, p.468) depicts this the change in organizations environments or "domains" very well.

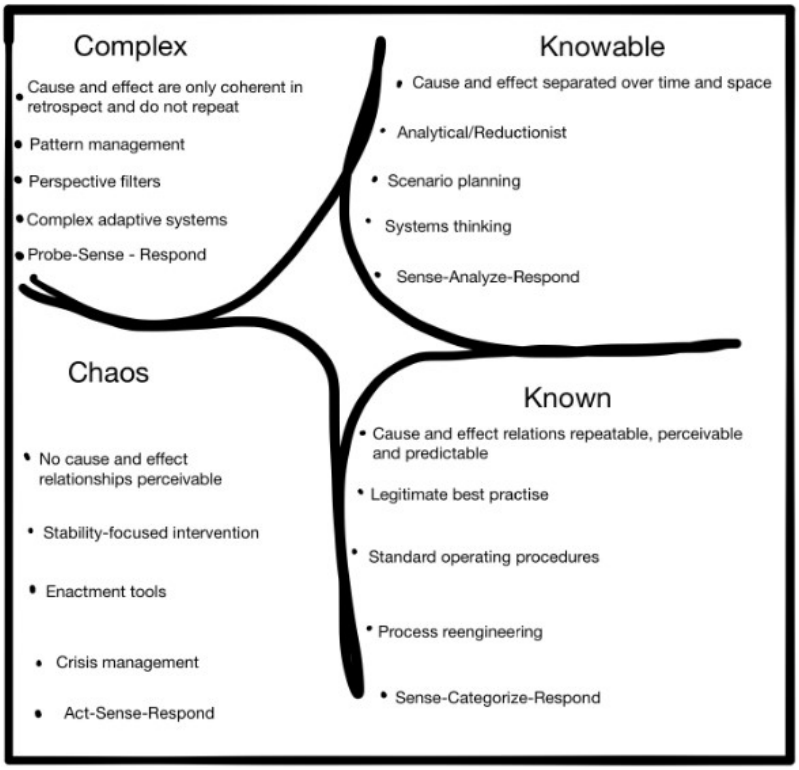

Figure 1 Cynefin-model

The environment that organizations act is turning increasingly *complex* (Kangas et al., 2019, p.7; Kurtz & Snowden, 2003), from the domain of complicated (*Knowable*, Kurtz & Snowden, 2003), as seen in Figure 1 (Kurtz & Snowden, 2003, p.468). This means that the organizations themselves cannot rely on the ability of prediction or control, but instead being *adaptable* (McCrystal, 2015, p.102) and *resilient* (Boin, 2013). This is the same property that is described by van Fenema (2004) as *elasticity*, which is described as a capability to sustain coherence and order even when in unexpected situations and in limited ability to communicate. The more uncertainty grows the more this adaptability, resilience or elasticity is needed (Van Fenema, 2004, p.135).

Traditional "Command"-style structure relies on the ability to control and predict. There the structure is build top-down; managers plan details, breaking down complicated goals into subgoals and simpler tasks for the level below. These kinds of organizations work like clockwork, maximizing efficiency like a

fantasy of Taylor (Taylor, 1911). This in turn limits the ability adapt and react, since in complex environments it is impossible plan all scenarios or create instructions for every event (van Fenema, 2004; Grant, 2003).

The increased need to change relates to the notion that the more hierarchical and mechanistic, and the larger a company is, the more inertia it has (Mintzberg, 1980). A good example of a hulking, hierarchical organization is that of the US military, since military organizations are generally build upon strict command-structures. However, when faced with an opponent, that could be described in business terms having the speed of a multitude of Lean Startups, it had no other choice but to improvise, adapt and overcome. This meant that it had to choose between *losing* and *winning*. It was literally, a life or death situation (McChrystal et al., 2015).

AQI (Al Qaida in Iraq) had an organizational and leadership model that the Task Force could not at first comprehend, let alone fight against it effectively. They had all the military resources and power to annihilate any military force dozen times over, but they were losing. Until they learned, adapted and gave birth to the Team of Teams (McChrystal et al., 2015). Team of teams and Team of Teams (in capital letters) in the Task Force context, is an organizational model that aims to have similar connections between teams as are between the individuals inside a team as seen in Fig. 2 (McChrystal et al. 2017, p.129). This is done by removing barriers of communication, aligning the goals of the teams and creating social connections (Fussell & Goodyear, 2017).

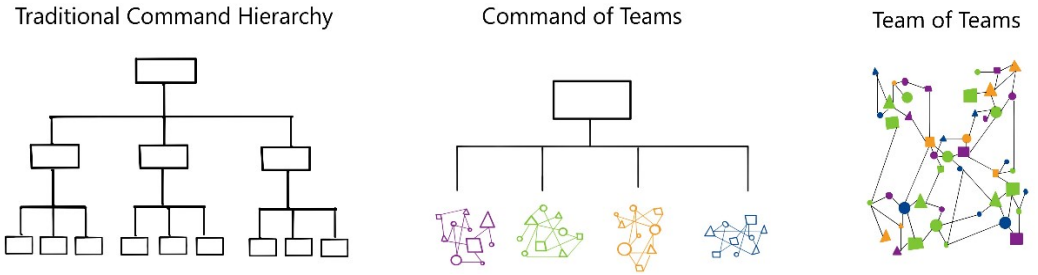

Figure 2 Comparison of organization models

1.2 Goals and methods of this study

This thesis has the goal of analysing the distributed cognition and team of teams through the means of a literary review, and as a synthesis describe team of teams with the lens of distributed cognition. Since the aim of this thesis is to reflect an organizational model, the literature search on distributed cognition is done this in mind. In practice, this means that more than trying to reflect only on the general topics of distributed cognition, a more practical view had to be taken. This meant that a suitable framework was searched, that was more oriented towards practical applications than on philosophical discussion. As a result, the Distributed Cognition for Teamwork (DiCoT) was used as a base for

the reflection. The DiCoT model is divided into 27 principles, that are formed under five themes: *social model*, *physical model*, *information flow model* and *evolutionary model*. The principles and themes are based on literature and research on distributed cognition. The research goals and questions are the following:

1. How is distributed cognition implemented in current literature?
2. To provide coherent image of the team of teams organizational model.
3. Can distributed cognition be used to analyse the Team of Teams model?

The method of the literature review has been to first use search terms with online databases and after that continue by using backward search to see the references is these articles, as well as forward search to see who has cited the articles. Practical screening for purposes of what was to be included or excluded was done. This was practically divided into three parts: those relevant for distributed cognition, those relevant for team of teams, and supportive sources. Supportive sources were considered as describing the topics around the main context, such as complexity, organizations, and social network theory.

Peer-reviewed academic sources were considered as the main source of information. However, especially on the Team of Teams context, sources other than academic studies were used, since they often contained information on the implementation, context, and detail as well as precise description of the method. As an empirical study is out of the scope of this thesis' resources, instead of dwelling into an organization by empirical methods, a more theoretical reflection is done comparing the McChrystal et al. (2015) described Team of Teams and the overall themes of the DiCoT.

The literature analysis has been done in perspectives of team of teams, distributed cognition and the combination of these two. The search has been done from Jykdok, Google Scholar and from IEEE, among others. In selecting sources, the major emphasis was on peer-reviewed research articles. However, in cases such as case-examples and in describing the backgrounds of the themes, there has been other sources used, with discretion. When able, all publishers have been checked via Jufo to see what level they are as a publisher. Primarily the terms used in research were formed from the word-combinations of "distributed cognition", "team of teams", and the combination of the two. Other relevant searches were made using "extended cognition, extended mind", "DiCoT".

The structure of this report is as follows: Introduction, description of distributed cognition, description of team of teams and then using distributed cognition in reflecting the Team of Teams from the Task Force context. In this synthesis chapter, the Team of Teams if divided in topics that follow the Fussell and Goodyear (2017) definition of Team of Teams. These topics are then described and reflected using distributed cognition. After this, the discussion section is presented where the results are highlighted and lastly a brief summary is done in the conclusions section. A more detailed summary of the DiCoT model, combined with examples derived from Team of Teams, can be found from the Appendix 1 (Furniss et al., 2006; Vasiliou et al., 2017).

2 DISTRIBUTED COGNITION

Distributed cognition stands at the intersection of socio-technological systems and as such represents an interesting subject from both the field of technology and sociology. While being an approach to cognitive sciences, distributed cognition is more than the study of the individual mind or individual cognitive functions. Distributed cognition could be also described more as a framework for *studying* cognition, instead of just as a *type* of cognition. Much of the ideas of distributed cognition can be attributed to Hutchins (1996), whos' seminal work on navigation on a naval aircraft carrier describes how knowledge and cognition are distributed socially, and is influenced by people, artefacts, situational context and their interaction. Distributed cognition, as also described by the Extended Mind model (Clark & Chalmers, 1998; Rowlands, 2009), is thus about extending the mind into the broader world, instead of just situating in the individuals' head.

2.1 Basic concepts of Distributed Cognition

Distributed cognition, as Perry (2003, p.194) articulates, has its roots on the need to understand topics such as problem solving and information processing. This is especially in the context of larger units than just individuals; such as groups of people, their activities and tools that they use.

As Thagard (2005, p.206) writes, distributed cognition basically means that instead of thinking happening in individual minds, it actually happens through the co-operation of teams or groups of people. It has been common to credit individual thinkers as the solvers of problems, while in today's world it is teams and organizations that work and solve those problems together (Hutchins, 1996).

There could be said to be three distinct types of distributing cognitive processes (Thagard, 2005, p.207). The first is the *distribution across members of a social group* – as an example with students working on a team-assignment (Xu &

Clarke, 2012). Second type is *coordination with external structures* such as computers, notebooks etc. The third type is *distribution through time*, when people continuously interact with objects and others, so that previous events influence the events in the future. An example is doing calculations for a specific idea, writing them down and using them later when solving a problem with a team (Hutchins, 1996).

To describe the distributed cognition that is used in this thesis, it feels necessary to argument what is *not* meant. The term distributed cognition or cognitive system or any combination of the two, is not to mean a consciousness, or an entity that can think or reason *like that of the human mind*.

Instead, it is meant primarily as the distribution and propagation of information through the system that comprises of human minds, cognitive artefacts, groups of people, space, and time. This is to not take part in the philosophical discussion for two purposes: it takes away from the limited resources that there is available for this thesis, and it is not relevant for this topic at hand. However, this is not to exclude the emergent cognitive properties, that are meant by Chicoisne (2006), since they are used to classify something as a distributed cognition.

2.2 Use contexts

Theories on Distributed Cognition have been applied to variety of contexts, such as

- Crime Scene Investigation (Baber, 2010)
- Crisis Management in COVID-19 (Lee at al., 2020)
- Aviation operations (Stanton et al., 2019)
- Human-dog systems (Amon & Favela, 2019)
- Railway operations (Andreasson et al., 2019)
- Field of educational technology (Shutkin, 2019)
- Healthcare team interactions in a birthing unit (Ashoori et al., 2014)
- How submarine returns to periscope depth (Stanton, 2013)
- To study information flow in dispersed agile teams (Sharp et al., 2012)
- Reflecting the actions of military coalitions (Smart, 2010; Smart & Sycara, 2012)
- Modeling Organizational Cognition (Secchi & Cowley, 2018)
- Analyzing Military Systems (Cortexia, 2020)
- In study of Software Design (Mangalaraj et al., 2014)
- The seminal work of Hutchins in *Cognition in the Wild* (1996), describing the navigation of a ship and its crew

2.3 Frameworks and models

There are various frameworks and models, that can be used for a "lens" for studying different contexts with distributed cognition, these include:

- Distributed Cognition for Teamwork (DiCoT) model (Furniss et al., 2019),
- TCWA - Team Cognitive Work Analysis (Ashoori & Burns, 2013; Ashoori et al., 2014),
- The Resource Model (Wright et al., 2000)
- Determining Information Flow Breakdown (DIB)
- and Event Analysis of Systemic Teamwork (EAST).
- Also, the Chicoisne (2006) Model with four distinct quadrants
- as well as the prosposed five functional requirements of tech in Distributed Cognition systems by Seagull et al. (2003, p.1521).

Chicoisne (2006, p.221) describes a framework of distributed cognition with four distinct quadrants as seen in Fig. 3. This model takes into account two linear scales: one axis is for the aggregate – emergent property and one is cognitive to non-cognitive. Aggregate is about the system being "sum of its parts". Emergent means completely new abilities that rise from the system.

Chiscoisne (2006) describes it hard to come by systems that would have emergent properties that a human brain could not come up with, that distributed cognitive systems are more like sidekicks that amplify and increase our cognitive abilities. He even continues that it would be near impossible to perceive such emergent properties directly. Chicoisne (2006, p.39) also writes that most human groups that cooperate, would go to the quadrant I, since usually their members can be interchangeable. Thus, they could be better be described as *collaborative cognition* (Harnad, 2005).

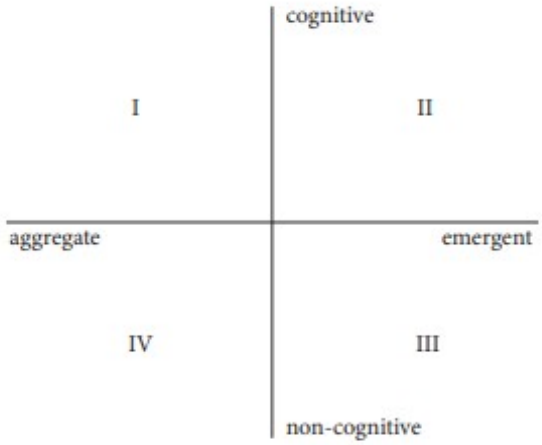

Figure 3 Quad-model of Distributed Cognition

From a technological perspective, the five functional requirements proposed by Seagull et al. (2003, p.1521) are interesting. They are meant to reflect technology in systems of distributed cognition, and to provide a reference for analysing such a system. To increase distributed cognition, used technology should:

1. Serve as a common referent for communication
2. Provide communal memory tool for planning
3. Serve as a catalyst for collaborative and Distributed Cognition
4. Allow parallel manipulation for multiple user-groups
5. Allow flexible content-reconfiguration

On the next chapter, the Distributed Cognition for Teamwork (DiCoT) is presented in more depth and length, because it is one of the most structured models available and has properties that make it well suited for further reflection in this thesis.

2.4 DiCoT-CL

Most methods in analysing the design and use of a system focus usually on singular user and one device systems. Thus, solutions are needed, that take into account systems that are mobile, ubiquitous, have a distributed and collaborative nature (Blandford & Furniss, 2005). Distributed cognition serves this purpose, yet it has had criticism of being too ambivalent and not structured enough to provide implementable, practical ready-to-use method (Rogers, 2000).

Cognitive ethnography is often the main method of studying cognition. However, as this is more of a collection of different techniques. To respond to this there has been several different models to bring more structure, such as those listed on the chapter 2.3. A structured framework, or a model, that can be used when describing complex cognitive systems is the DiCoT model. DiCoT is based on contextual design (Beyer & Holtzblatt, 1999), and offers rigor, structure and analytical support, and from the viewpoint of this thesis, is seen as the suitable model to reflect the Team of Teams.

As Blandford and Furniss (2005) explain, DiCoT and later DiCoT-CL, was created for the need of a more rigid framework for analysing complex socio-technical systems. The added CL comes from Concentric Layers. DiCoT-CL consists of principles that are derived from research and literature of distributed cognition. These principles are divided into five themes. The Concentric Layers come from reflecting them on micro-, meso-, and macro-level as seen in Fig. 4 (Furniss et al., 2019, p.78). On the first use cases of the model, there was emphasis on the three “main” themes: Physical Layout, Information Flow and

Artefacts (Blandford & Furniss, 2005), yet later and more recently, there has been more use on all five different themes (Vasiliou, 2017, Furniss et al., 2019).

The five themes by Furniss et al. (2019, p.77) are:

- *Information Flow*: tasks, activities, processes.
- *Artefacts*: how the design of tools, technologies and external representations influence the information processing of the system.
- *Social*: roles people have, knowledge, skills, responsibilities, expertise.
- *Physical Layout*: impact of the physical layout to flow of information)
- *Evolutionary*: distribution of cognition over time, short-, medium-, and long-term; planning and preparation for work, system evolving over time.

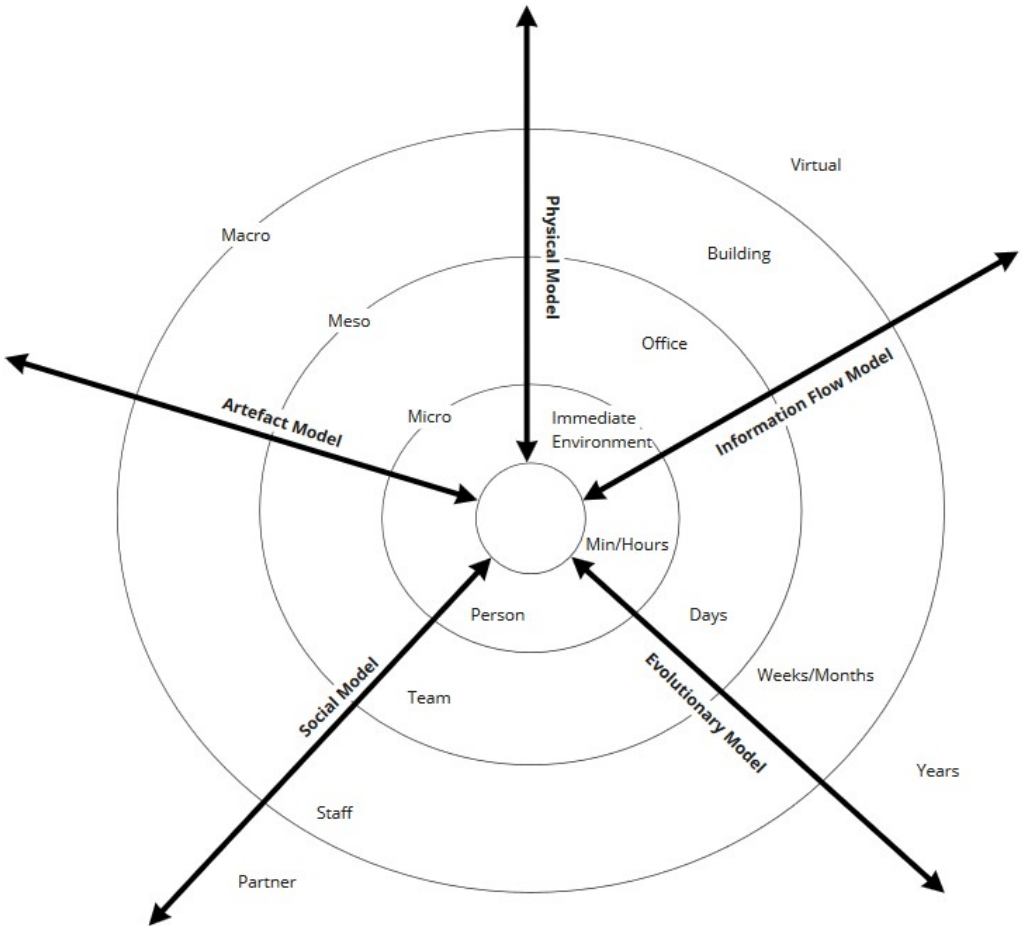

Figure 4 DiCoT-CL

An example of the Concentric Layers from a physical perspective could be *immediate environment* (micro) of the members(s) of the organization, such as the table or spot where one is working, with a computer. *Co-location* (meso) where people gather or are situated physically near each other to work and the *communication system* itself (macro), with virtual forum, offices, cafeterias, virtual meetings, digital communication platforms etc. (Furniss et al., 2019, p.78, fig. 1).

DiCoT has a variety of recent contexts, that it has been applied to, such as:

- Studying the use of infusion devices in operating theatres (Berndt et al., 2014)
- Patient Safety (Furniss et al., 2019; Garfield et al., 2020)
- Ambulance Control Room (Furniss & Blandford, 2010)
- Collaborative Learning (Vasiliou, 2017)
- Simulation-based team training (Rybing et al., 2015)
- Infection Control (Hussain & Weibel, 2016)
- Designing teamworking systems (Furniss & Blandford, 2006)
- Blood Glucose meter usage (Furniss et al., 2015)
- Health informatics (Furniss et al., 2019)

In the original model there were 22 principles (Blandford & Furniss, 2005; Furniss et al., 2017) but it has since been developed by Vasilou et al. (2017) by adding five more principles. These principles can be found on the APPENDIX 1. As described by Furniss et al. (2019), the DiCoT-CL model with its principles and themes should not be viewed as a *checklist*. Instead, it should be used in a semi-structured way, reflecting the context it is applied to, since many of the principles and themes can have overlap.

3 TEAM OF TEAMS

By team of teams in the context of this thesis I mean an organizational model with the key principles being decentralization of decision making, breaking the silo-structure of traditional organizations and implementing connections between teams that are similar to individuals in teams. Since the Task Force (McChrystal et al., 2015) case is described multiple times in this thesis, and it offers a specific context for a team of teams model, when describing the Task Force model specifically, "Team of Teams" is used with capitals. When the more broad, general method is described, "team of teams" with lower case is used.

3.1 Background of team of teams

The concept of team of teams has a history of its own before the adoption of the Task Force in Iraq. One of the earliest mentions of team of teams is by Oyer (1977), when he describes the need for leaders for dynamic organizations. Major contribution towards promoting the team of teams model has been done by Bill Drayton, who founded the non-profit, social entrepreneurial organization Ashoka in the 1980. Drayton describes his "team of teams" as an organization that functions as a "constellation of teams" that come together around specific, common goals. Coordinating executive team is at the centre of this constellation but the actual teams work together in fluid, constantly changing ways (Meehan & Jonker, 2018; Drayton, 2013). The main points of this model are decentralized autonomy, meritocracy, and a sense of partnership, which are similar to the Team of Teams McChrystal et al. (2015) as well as Fussell and Goodyear (2017) describe.

Earlier work that relates to the team of teams model has been done by Forrester and Drexler (1999) to build a team-based organization. They describe the need for a team-based organization model in situations when speed is of priority value, when there is a rapidly changing environment and when the need of

innovation is high. This Team-Based Organization Model (1999, p.38) is in part similar to what McCrystal et al. (2015) and Fussell and Goodyear (2017) describe, which is not a surprise in itself, since organizational innovation rarely happen in a vacuum (Dombrowski et al, 2007, p.190). However, especially in the military context, this level of organizational change that is introduced by the team of teams, it can be considered having an innovative aspect to it

3.2 Use contexts

The Team of Teams model has been implemented in different contexts, such as:

- Trauma Surgery (Jenkins, 2016)
- Combined Arms Route Clearance (Schmidt, 2015)
- Building Nanosatellites (Kinsner et al., 2013)
- Delivering cancer care (Henry et al, 2016)
- Design project course at Stanford University, ME310-Global (Leifer & Meinel, 2016)
- Organizing social entrepreneurship (Drayton, 2013)

Team of Teams in direct relation and reference to the McCrystal & Fussell model/method has been implemented and reflected in variety of contexts, such as in:

- School environment (Young et al., 2016)
- Emergency services (Washko, 2016)
- US Department of Energy in the Exascale Computing Project (Raybourn et al., 2019)
- Corporation Management: case Under Armour Ltd (Fussell & Goodyear, 2017)
- Organizing the Finnish Navy in Complex Environment (Ågren, 2019).
- Model for Collaborative Cyber Security (Doelen, 2016)
- Model for organizing Cyber Security (Doan & Barnabo, 2017)
- The Team of Teams has even been tried to be patented as a digital system by the Namely Inc (Patent nr. US 2014/0278659 A1)
- Counter Russian meddling in the United States political processes (Farwell, 2018)

3.3 Team of Teams in the Task Force

The Task Force in Iraq needed to transform itself from a solid-line, high-inertia bureaucracy, that had extremely efficient teams and professionals, but lacked coordination between teams and partner organizations, into something that had both the ability to coordinate complex action and have agility of a small organization. Enter the Team of Teams; agility, adaptability of small teams is scaled, replicated on a large scale through the entire organization, transforming the superstructure into one team with *shared consciousness* and *empowered execution* that can be seen in Fig. 5 (McChrystal et al., 2015, p.129).

It achieved this by utilizing the team of teams mentality and created an organizational process and model, that was later called as Team of Teams. As the process was retrospectively analysed, the process and method could be formalized under coherent themes or components. These are described by McChrystal et al. (2015) as Shared consciousness and Empowered execution and later in more detail by Fussell & Goodyear (2017) as The Hybrid Model, Aligning Narrative, Interconnection, Operating Rhythm, Decision Space and Liaisons.

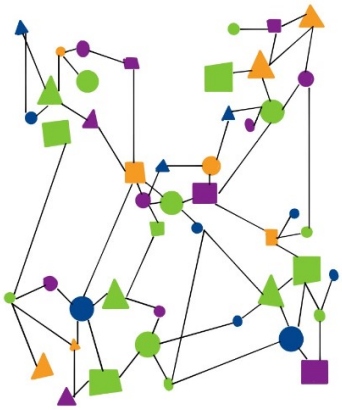

Figure 5 Team of Teams organization model.

Shared Consciousness was created through transparency and lateral connectivity. (McChrystal et al, (2015, p.163). *Aligning Narrative* was formed as the core message of the organization and was meant to be a guiding narrative for every individual (Fussell & Goodyear, 2015, p.58) Interconnection is meant to describe the way, how the Shared Consciousness that McChrystal et al. (2015) is created and is about the process of enabling free information flow through technology and social connections (Fussell & Goodyear, 2015, p.77).

Empowered Execution is the enabling of those closest to the action, and with latest information to make decisions that normally would be higher than their level in the organization (McChrystal et al., 2015, p.213-214).

Operating rhythm is meant to represent the need and method of aligning the actions from tactical, operational, and strategic levels, in order to synchronize the Empowered Execution (Fussell & Goodyear, 2015, p.141-142). *Decision Space* is meant to act as a boundary check for the empowered teams and individuals and is used in conjunction with the operating rhythm to be updated on continuous basis.

The *Liaison networks* are created by forming social connections through exchanging members of teams that are normally very distant in functions but interlinked from a systemic perspective. Finally, the *Hybrid Organization* is formed by the different phases and processes that are listed previously, meaning the combination of a hierarchical organizational structure with lateral and vertical informal connections (McChrystal et al., 2015; Fussell & Goodyear, 2017).

4 TEAM OF TEAMS FROM DICOT PERSPECTIVE

The fact that distributed cognition is used both in many variety of contexts, ranging from military coalition scale (Smart & Sycara, 2012; Smart, 2010) to agile teams (Sharp et al., 2012), provides good ground for using it in the context of Team of Teams. Since the Team of Teams model is meant to be implemented in large organizations, by transforming it to work like a *team*, the frameworks that reflect teamwork were inspected. DiCoT was selected and is used as a framework on this chapter.

In the following subchapters the elements of Team of Teams are reflected though distributed cognition and especially with DiCoT themes. Further aligning can be found on Table 1 (Appendix 1; Furniss et al., 2006; Vasiliou et al., 2017), where the specific DiCoT principles are arranged with examples from Team of Teams. When inspecting the elements of Team of Teams and themes of DiCoT, one should take into account that they in both cases they are highly overlapping and interrelated and thus should not be considered entirely separate entities. Next, the different topics that Team of Teams is composed of (as per Fussell & Goodyear, 2017) are described. The topics are described first in a general detail, and then reflected more through distributed cognition.

4.1 Aligning Narrative

The aligning narrative means statement, an overall goal and *how* to get there. It is something, that describes what the organization wants to be, what it wants to achieve and how will it get there. This statement is meant to penetrate to every individual in the organization and act as a strategic guide for collective coordination (Fussell & Goodyear, 2017, p. 58-59). This Aligning Narrative was presented explicitly by the General McChrystal (p.57-58) but relied very much on social contagion to propagate important information through the organization.
An interesting detail here is the importance of visual expressions and attitude of the leader who is visually seen on the virtual forums. As McChrystal et al. (2015,

p.228) says, every nod, expression and "taking glasses off", will instantly be evaluated by the viewers. That is why it is of paramount importance, what is done both verbally and non-verbally. This has to do with *emotional contagion* (Hatfield et al, 1994), what Thagard (2005, p. 207) implies being one aspect of distributed cognition. Strong focus should also be on the person that is organizing and leading the meetings; for example, setting agenda and allocating time for participants to comment and discuss (Fussell & Goodyear, 2017, p.104).

In this, the aligning narrative can be seen though the themes of Social model and Information flow model (Furniss et al., 2019). One of the aligning narratives goals was to break the silos and encourage trust and open information sharing. Withholding information on the basis of "tribal" loyalty to own team can be seen through the principle of Social Circles of Privacy (Vasiliou et al., 2017). That is part of the Social model, as what individuals keep secret when in example, working in groups; this has direct consequences of the way information is distributed within the group.

4.2 Interconnection

To make it possible to communicate the aligning narrative to every individual in the organization, traditional "mail & intranet" will not be enough. Instead, physical locations, with shared displays were made more open (Fussell & Goodyear, 2015, p.83), videoconferences were open for everyone, and during the discussion forums that the conferences provided, participation and open sharing was encouraged constantly to provide an example and create social contagion of the aligning narrative (2015, p.59-60 and p.89). Interconnection was also promoted by recognizing social hubs (Kim & Lee, 2017), that could spread the narrative efficiently (Fussell & Goodyear, 2015, p.76-77).

Technology plays a vital role in the creation of a Team of Teams. Fast, scalable communication is a must – especially if the organization is geographically dispersed over a wide area. Also, having a very large organization – not to mention having partner-organizations, makes colocation impossible. Communication is a fundamental part of Team of Teams, as communication is essential in countering uncertainty (Van Fenema, 2004, p.138).

People are usually willing and know that it is better to cooperate. Still, they will only do it if they can see the full picture of what's at stake, and they trust the other parties to do the same. This is often described as the Prisoners Dilemma after the famous Flood–Dresher experiment (De Herdt, 2003). This means that people in complex, high-dependency environments, where a team needs to act and think as one, need the ability for *systemic understanding* and *strong lateral connections*. These are the goals of interconnection.

Systemic view in this context means in practice the ability to substitute communication with knowledge. When people know about their counterparts' work, it lowers the need for communication (Van Fenema, 2004, p.137). This in turn enables people to know what others need in order to accomplish their job.

This is highly related to the theme of Information flow (van Fenema, 2004, p.136; Hutchins, 1996).

However, systemic thinking is often forgotten, when under pressure (van Fenema, 2004, p.136). That is why it is important to emphasize and hone it as a routine and negate this phenomenon with efficient communication (2004, p.138) and this was exactly what was done in Team of Teams (Fussell & Goodyear, 2015, p.59-60).

Interconnection can be attributed to three themes: Artefact model, Social model and Information flow model (Furniss et al., 2019) as there are clearly aspects of principles at play that can be referenced. As an example, in part of the artefacts, the importance of TOC colocation can be highlighted, where shared large displays could be seen by all. Those displayed what was the current situation and what needed to be done (Fussell & Goodyear, 2017, p.172). These can be linked with the principles such as Representational – Goal parity and Coordination of Resources (Furniss et al., 2006).

The use of these different technologies is also in line with the requirements proposed by Seagull et al. (2003), as they serve as a common referent for communication and provide communal memory tool for planning They also serve as a catalyst for collaborative and distributed cognition, allow parallel manipulation for multiple user-groups and flexible content-reconfiguration.

4.3 Empowered Execution

Empowered execution is explained simply as giving teams the access to key data, invitation to relevant strategic discussions and enabling to independently use cross-boundary connections. Empowered execution – decentralized decision making - can bring very rapid reaction times in smaller team levels (McChrystal et al., 2015, p.213-214). In the Task Force, this could be summarized in a sentence: If something supports the action, and is not illegal or immoral, do it. Leadership was more as a gardener, asking how they can help the action subordinates were pursuing (2015, p.214).

However, the more power is given to a team, the more the risk of a larger wrong decision comes, which in complex environments and systems tend to cascade into even larger ones. This is mitigated with the *operating rhythm*, a synchronizing tool to keep the boundaries of decision making in check and align strategic efforts with the action at the tactical level of decision making (Fussell & Goodyear, 2015, p.141-142).

In empowered Execution, the cognitive load of decision making is distributed from the leaders to those closer to the action itself. This removes the need for *transformation* and *buffering* the information for the decision maker, and those with the most relevant information can act. This can be perceived through the Information flow model (Furniss et al., 2006). However, this empowerment did not happen overnight and required facilitation, encouragement and *adaptation* from both the leaders and their subordinates. As such, this can be reflected

with Evolutionary model (Furniss et al., 2019). Social model is relevant with the principle of Social Emersion (Vasiliou et al., 2017), that happens when social roles emerge in a group. In the ToT context, experience was often what mattered; sometimes turning subordinates into key decision makers (McChrystal, 2015, p.213).

4.4 Operating Rhythm

Operating rhythm basically means coordinating actions so that the strategic-, operational- and tactical-level of doing is working towards the same goal. Operating rhythm also makes sure, that relevant and up-to-date information is shared, and empowered execution has its proper *decision space* (Fussell & Goodyear, 2017, p.129). This can be seen to be connected to the evolutionary and social themes of distributed cognition (Furniss et al. 2019) as the Team of Teams system develops over time and its actions are synchronized and aligned in temporal aspects.

4.5 Decision Space

Empowered execution requires managers to learn how to let go. We have learned to live in a world full of narratives about heroic leaders, who know everything and lead their people to victory. In a complex world, this is highly unrealistic. Not only this, but our current technology, that should make it easier to communicate and share work, is often actually used to increase control. This brings home the negative effects of information overload and micromanaging.

Eyes-on-Hands-off is the approach that McChrystal (2017, p.213-215) started to adopt, and even if it was not easy at the start. He quickly noticed that now that those people who had the freshest knowledge on the matter made the decisions, the result was not only in faster but better decisions.

Teams and individuals are more committed and motivated, among other benefits, when they are both empowered and having the ownership of decisions (Conger & Kanungo, 1988). However, simple delegation is often not enough: one needs to deliberately encourage decision-making in all levels. This happened often through the O&I (McChrystal, 2015, p.213-215). Empowerment has been seen as one of the key characteristics in the success of large but innovative companies, such as Google (Steiber & Alänge, 2013, p.213), however there needs to be tool that make terms of empowerment more explicit, such as the *decision space.*

Shifting discussion from seeking approval to seeking support is a fundamental part of decision space (McChrystal et al., 2015). By asking once for confirmation, there is the possibility to enlarge the decision space, so that in the future similar actions can be just acted upon, and the purpose of leaders is not

to authorize, but to enable by supporting. This decision space is then aligned and synced again with operational rhythm. (Fussell & Goodyear, 2017). The decision making is thus distributed more closer to the action and lessens the amount of information processing needed for decisions and actions, having close relation with themes such as Information Flow model and Social model (van Fenema, 2004; Furniss et al. 2019).

4.6 Liaison Networks

Inside an organization, each internal team sends an individual as a liaison to another team. In the Task Force, this could be an analyst that located with a SEAL team or a SEAL officer might be located with the analysts (McChrystal et al., 2015, p.166). In an enterprise scenario, this might mean as an example someone from the manufacturing go to sales and vice versa.

This happened with external partners too: the best people were sent from both sides as representatives. However, this only worked when the liaisons were valuable to their own teams and they were trusted and respected. The liaisons should have so good ties with superiors, that they would "recognize their voice when they called you at two in the morning", as Fussell & Goodyear (2017, p.213) describes. This meant that sending a person would/should hurt the team, but this act would prove to be was much better for the entire organization. As McCrystal et al. (2015, p.180) as well as Fussell and Goodyear (2017, p.217) witnessed, these exchange programs build high trust and strong personal relationships, and when partner organizations saw that information is shared as well as the best people, they begun to reciprocate.

Liaison network can be seen from through the themes of Social model as well as from an Information flow models' perspective. In essence, the liaison program focuses on the usage of social context in collaboration, cooperation and communication. However, this is also essential from an information flow perspective, since people essentially through social connections act as information conduits, hubs, buffers and transformers (Furniss et al., 2016; 2019).

4.7 Hybrid Organization

The previous topics enable the creation of a hybrid organizational model as seen in Figure 6 (Fussell & Goodyear, 2017, p.45). This hybrid organization has the benefits of what usually were considered as properties of adhocracy, standard team-based organization and a network-organization. However, the organizing challenges, that are related to creating fast-paced, empowered teams and informal networks are controlled by the existing "hard" hierarchy-structure, that aligns and synchronizes the level of empowerment and goals in continuous

rhythm (Fussell & Goodyear, 2015). This means that the hybrid organization can react, adapt and more resilient like team, but maintaining rigor in its operations that enable it to have coherent cooperation, clear goals and alignment in every action.

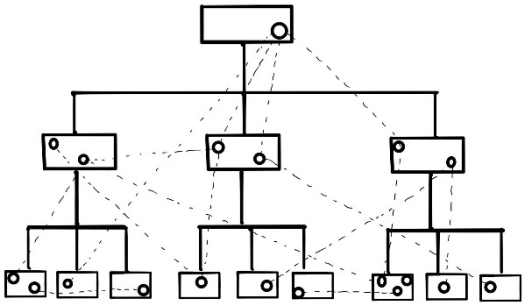

Figure 6 Hybrid Organization.

5 Discussion

The research on distributed cognition provided several models and frameworks, that could all be used to start to describe Team of Teams, if not as a whole, at least portions of it. However, DiCoT model was selected due to its structured composition and for its flexibility. This was done to avoid the work turning into a mosaic of different perspectives. However, some other models are useful to go shortly through, since they can offer value for development of framing organizations with distributed cognition.

According to the Chicoisne (2006) model of quadrants, many organizations could orient itself to the Quadrant I and as such be more defined as a collaborative cognition (Harnad, 2005), than distributed cognition. This is on one hand defined by Chicoisne (2006) as being because a) members of the organization could be changed without having an inhibiting effect on the outcome and b) because truly emergent properties should be the type of that can't be similar to those that the individuals have: if a person would just be smarter, faster and have a better memory, he could one do the same as a team.

The model that Chicoisne (2006) proposes, can offer a good start to evaluate the "strength" of a distributed cognition in an organization, even though its definition of what an emergent property with high consciousness remains perhaps overly vague. However, from a technological standpoint, requirements by Seagull (2003) can act as reference tool for analysing and designing of a distributed cognitive system. Both in combination with an overall model like the DiCoT, can provide content for the limited research on cognition and organizations, as Secchi and Cowley (2019) describe. Furthermore, the perspective of DiCoT-CL could be widened to encompass even entire organizational ecosystems – such as business networks (Möller et al., 2005) or startup ecosystems that Sipola (2016) has researched.

The first research question of "How is distributed cognition implemented based on current literature?" was answered through the literature review. As can be seen from the results of the search, in the last decade there has been a large variety of different contexts that the distributed cognition has been reflected and implemented on. Majority of the contexts have been in relation to

group- or teamwork. This is understandable, since the concepts of distributed cognition mainly relate to the interactions between individuals and artefacts. Interestingly, distributed cognition is often related to High Reliability Organizations (HROs), where people work with advanced technology and in high-risk environments (van Fenema, 2004, p.134), such as aviation (Stanton et al., 2019), healthcare (Ashoori et al., 2014) and in the military (Cortexia, 2020).

The second research goal of "To provide coherent image of the team of teams organizational model" was also answered through the literature review. Team of teams model can be seen to be increasingly articulated in the literature during the recent years. Especially following the McCrystal et al. (2015) and Fussell and Goodyear (2017) publications, there has been implementations that are directly related to them. This is natural, since the publications have offered the model to be articulated more coherently as well as bringing it to a spotlight. Furthermore, the same pattern can be seen from the team of teams research as in the Distributed Cognition, as it has been implemented in ROI contexts such as emergency services (Washko, 2016), trauma surgery (Jenkins, 2016) and in military contexts (McChrystal et al., 2015). In a general sense, the fact that these implementations are often related to ROI contexts, highlight the effectiveness and importance of teamwork.

The third research question "Can Distributed Cognition be used to analyze the Team of Teams model?" was answered through synthesizing the results of the literature review. The DiCoT model was seen to be useful in providing structure on reflecting different aspects of distributed cognition on an organizational context. The main concepts were perceived through the different themes as well as principles of DiCoT, as in depth as the details of the sources allowed.

5.1 Challenges and limitations

The major challenge of combining distributed cognition with team of teams relates the *scale* and *scope* of reflection. Using distributed cognition in a broad sense can be used to analyse team of teams, however the practical value can be limited. This is due to the fact that applying distributed cognition without any structure can be too general and prone to wide variety of interpretation. This is mitigated by using a more structured framework of DiCoT.

The purpose of this thesis was to analyse Team of Teams with the resources available: literature descriptions were used to provide insights into what details are in the Team of Teams model itself. As the DiCoT model is usually meant for more detailed empirical analysis, the challenge was also how to provide enough details to make observations. As Rybing (2015, p.9) concludes, DiCoT is used primarily as analysing tool for small teams. However, it could be escalated in the future to be used in larger organizational context.

When inspecting a large organization with distributed cognition, insights can be found even with more abstract knowledge. This is one strength that the

DiCoT offers, highly specific and detailed analysis is possible, yet not necessarily practical or feasible. Another challenge was, how to arrange, reflect and describe the different Team of Teams elements, since they are highly interrelated and overlapping. In any case, some structure was needed and in this, especially the Fussell and Goodyears' (2017) structure was used.

5.2 In relation to Information System Sciences

Distributed cognition in general, with its three main concepts (social, artefact, time) fit into the field of Information Systems very well. Distributed cognition has a large touchpoint with the technical side of the sociotechnical continuum, through the different artefacts that are part of the distribution of cognition. This is however interlinked with the social aspects, since artefacts are often the medium in which social interaction happens with. Time as a temporal aspect is somewhat neutral in respect to the sociotechnical continuum.

Team of teams as an organizational model can be argued to be in the field of Information Systems, and it is very much related to IS theories such as Social Network Theory (Cote, 2019), Socio-technical theory (Clegg, 2000) and Systems thinking (Cabrera et al., 2008; Cabrera et al., 2015) in general.

Social networks theory (Liu et al., 2017) has the main point of emphasizing the connections between nodes instead of the attributes of the nodes themselves, and this is what McChrystal et al. (2017) points out too. This perspective in one of the cornerstones of Team of Teams, that interaction and connections between persons is what is needed to create team-like superstructure that composes of teams having connections like those inside the teams themselves.

In the Team of Teams model, there is strong emphasis on utilizing hubs (Kim & Lee, 2017) in transmitting information, instead of using just the regular, traditional structural, vertical connections. Hubs, in the context of social network theories, are considered as very critical in idea adoption in groups and in dissemination and cascading of information (Kim & Lee, 2017).

In order to use and form Team of Teams effectively, especially in the context of large organizations, modern day technologies are in critical role. These technologies include tools for secure virtual meetings and conferences, laptops, computers, mobile devices, fast connections with large bandwidth and naturally the software and cloud-based systems that enable these. McCrystal et al. (2015) points out, that this technology enables control on a vast scale, but instead of faster reaction, it usually leads to more inertia due to micromanaging. Instead of control, this technology should be used for sharing of information and knowledge.

In the context of using virtual videoconference that is open to everyone in the organization, the type of a more direct communication lifts the limits of information processing capability. Information processing capability can get overwhelmed in fast paced situations, such as in a crisis (Van Fenema, 2004, p.138).

Previously, the use of technology in communication has had strong limitations in relation to the number of people who can participate, low data richness, and limited ability for interaction (Van Fenema, 2004, p.138). Modern technology however has increased these capabilities enormously, enabling the creation of these teams of teams, that are described in this thesis.

As organizations become more global and dispersed, the run into complex challenges that are often have unique temporal, geographical and socio-cultural in contexts (Sharp et al., 2012, p.62). These challenges lead to difficulties, such as inadequate communication, process- and project-management problems, and disorganization of work (Sharp et al., 2012, p.62). The models such as team of teams can act as a response to these challenges.

In broader organizational and managemental context, as Grant (2018, p.148) describes the evolution of organizational models towards more organic structures having been steadily developing. As Grant continues (2018, p.149-150), he points out that a common element in different organizational changes are focus to coordination instead of control, importance of informal coordination and having individuals in multiple roles in an organization. The emergence of team of teams is thus a product of the time.

6 Conclusion

This thesis started out by framing the environment of organizations turning increasingly complex. Then a lens, distributed cognition, was introduced to serve as a perspective to view an organizational response to this complex environment, which was the second main concept, the team of teams. The team of teams model was then further elaborated, using more precisely the DiCoT model for analysing the main principles of Team of Teams in the Task Forces' context.

The findings of this thesis are that team of teams is an emerging organizational model, that has been implemented explicitly in several contexts lately. Further, the team of teams model has been developing a coherence during the end on last decade, mainly through the efforts of McChrystal et al. (2015) as well as Fussell and Goodyear (2017).

The findings relating to the distributed cognition can be concluded to be similar: the field has had a coherence in using its theories and concepts and has developed into several frameworks after the seminal observations of Hutchins (1996). Most notably, the DiCoT framework offers a valuable rigor for both analysing and design of teamwork.

The synthesis in this thesis provides a starting point for another use of the DiCoT model, which is to broaden its perspective into organizational study, especially due to its semi-structural form, which offers the possibility of focusing on specific details or larger constructs.

As brought up in the discussion section, this synthesis also provides though for thinking that are the concepts of resilient, adaptive and agile organizations and highly emergent distributed cognitive systems linked to each other, so that through DiCoT model, it would be possible to *design* resilient, adaptive and agile organizations?

This thesis makes the following contributions to existing literature: it is providing first example of connecting the Team of Teams model from a coherent distributed cognition perspective. It is also the first time the DiCoT model is used to reflect a broader organization. Further, it contributes to the limited literature on cognition and organizations and offers a possibility to further study

organizations from the perspective of distributed cognition, instead of focusing on more limited teamwork-contexts. As Secchi and Cowley (2019) argue, while there has been literature in recent years in relation to cognition and organizations, the field as such has not "taken off" (2019, 2.1). As a final word, possible further research is listed as following:

- Providing empirical studies on connecting the DiCoT-model with larger organizations
- Could an additional framework be created, where the strength of an organization from and distributed cognition perspective could be measured?
- Empirical studies on the possible connection of this strength of distributed cognitive system and results that relate to the ability to respond to environmental change, market success, KPI etc.

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APPENDIX 1 DICOT PRINCIPLES

Table 1 DiCoT Principles.

Theme and associated principle	Description
Physical model	Hollan et al. (2000) discuss the role of space in supporting cognition. They present examples of the use of space such as supporting choice and problem solving. In the case of ToT, space can be seen through multiple ways. One notable example is the arrangement of people and their stations in the JOC, Joint Operations Center (McChrystal et al., 2015, 160-161).
Space and Cognition	
Perceptual Principle	Norman (1993, p.72) argues that spatial representations provide more support for cognition than non-spatial provided that there is clear mapping between the layout of the representation and that which it represents. In the case of JOC, those that we in more critical need of information were situated closer to the centre of the room, the most current situations were shown as they happened (McChrystal et al., 2015, p.161).
Naturalness Principle	Similarly, Norman (1993, p.72) argues that cognition is aided when the form of the representation matches the properties of what it represents.
Subtle Bodily Supports	In interacting with the environment, an individual may use their body to support their cognitive process (Hutchins, 1996, p.236). An example of this is when one follows a route on a map and trails his finger along the path.
Situation Awareness	One of the key aspects of shared tasks is that people need to be kept informed of what is going on, what has happened and what is planned (Norman, 1993, p.143-145). The quality of this situation awareness can be influenced by how accessible the work of the team is. This is clearly demonstrated in the FOC as

	having display run with live-events, action loges and situation maps. The co-location, with proximity of key personnel enables seeing what others are doing. (McChrystal, 2015, p.161).
Horizon of Observation	The horizon of observation is what can be seen or heard by a person (Hutchins, 1996, p.268). For each person in an environment, this depends on their physical location, the activities they are close to, what they can see and the manner in which activities take plays. The horizon of observation of a person plays a large role in influencing their situational awareness. Close proximity of key personnel in the JOC enables seeing what others are doing, and having broad live displays of activity enables any individual in the room to see the entire situation independent of rank or role (McChrystal, 2015, p.161).
Arrangement of Equipment	From a DC perspective, the physical layout of equipment affects access to information, and hence possibilities for computation. This applies to the different levels of access to people, their conversations and their work as well as to physical representations and artefacts (Hutchins, 1996, p.197). JOC had a layout that enabled everyone to access anything and anyone fast but was also arranged so that those in most information-critical tasks were closest to the sources of information (displays, radio, comm. equipment). Everything was located in front of a wall of screens. (McChrystal, 2015, p.161)
Information flow model	Information moves around the system. This can be achieved in a number or different ways which have different functional consequences for information processing. These ways differ in their representation and their physical realization. Different mechanisms include: passing physical artefacts; text; graphical representations; verbal; facial expression; telephone; electronic mail; and alarms. Even inaction might communicate information (Hutchins, 1996). As McChrystal et al. (2015, p.228) points out, the simple act of taking glasses of in a virtual meeting can be interpreted in myriad of ways by others. In the ToT, main information channel was the "O&I", daily secure videoconference and a virtual forum (Fussell & Goodyear, 2017, p.165).
Information Movement	
Information Transformation	Information can be represented in different forms; transformation occur when the representation of information changes. This can

	happen through artefacts and communications between people. Appropriate representations support reasoning and problem solving (Hutchins, 1996). One important transformation is filtering, in which information is gathered, sifted and structured. In the context of ToT, as McChrystal et al. (2015) explains, especially the analyzing of intelligence information was critical (p.122); raid teams gathered data and information (p.120); the analysts would go through the material and produce actionable information and knowledge (p.169).
Information Hubs	Information hubs can be considered as a central focus where different information channels meet, and where different information sources are processed together – e.g. where decisions are made on various sources of information (Blandford & Wong, 2004). Busy information hubs can be accompanied by buffers that control the information to the hub, to keep it working effectively. In ToT, the principal information hub was the JOC (McChrystal, 2015, p.160-161) and as a virtual extension the O&I (Fussell & Goodyear, 2017, p.165); yet the implementation of liaison program (Fussell & Goodyear, 2017, p.5-6) meant that also hubs of social networks (Kim et al., 2017) - people with many connections - were used to combine different channels of information sources, acting as boundary spanners (Fussell & Goodyear, 2017, p.81-82).
Buffering	As information propagates around a system, there may be times when the arrival of new information interferes with important ongoing activity. This can create conflict and increase the chances of an error occurring, either because the new information gets lost or distorted or because the interruption provokes a mistake within the ongoing activity (Hutchins, 1996, p.195). Buffering allows the new information to be held up until an appropriate time, when it can be introduced.
Communication Bandwidth	Face-to-face communications typically impart more information than those conducted by other means, including computer mediated communication, radio and telephone (Hutchins, 1996, p.232). This richness needs to be recognized when technologies are redesigned. As McChrystal et al. (2015, p.228) explains, even minor gestures can convey information when using virtual videoconference. New technologies are bringing distant communication nearer the level of face-to-face

	communication and offer considerable bandwith, as with the O&I (Fussell & Goodyear, 2017, p.168).
Informal Communication	Informal communication can play an important functional role in the system, including the propagation of important information about the state of the system, and the transfer of knowledge through stories, which can have important consequences for learning how the system behaves (Hutchins, 1996). Using storytelling in the ToT context, the Aligning Narrative is formed to convey the mission of the organization. This was made explicit but also conveyed through informal way, using social contagion (Fussell & Goodyear, 2017, p.4 and p.16-17).
Behavioral Trigger Factors	It is possible for a group of individuals to operate without an overall plan as each member only needs to know what to do in response to certain local factors. These can be dubbed 'trigger factors' because of their property of triggering behavior (Hutchins, 1996). In the ToT context, this was apparent in example SF teams (McChrystal et al., 2015, p.136), yet this these actions needed to be aligned to serve the broader whole by providing systemic view for every individual (p.141).
Artefact Model	To support activities, people make use of 'mediating artefacts' (Hutchins, 1996, p.290). Mediating artefacts include any artefacts that are brought into coordination in the completion of the task. In the context of ToT, the presenters in the O&I would use a "agenda" file, where the general table of contents were found in advance, during and after the briefing, containing also links to relevant documents and contact information for communication on the specific activity (Fussell & Goodyear, 2017, p.102-103).
Mediating artefacts	
Creating Scaffolding	Hollan et al. (2000, p.192), argue that people use their environment constantly by creating "external scaffolding to simplify our cognitive tasks". In the ToT, when intelligence material was captured, it was bagged and labeled to provide additional information on the context where it was captured (McChrystal, 2015, p.121).
Representational – Goal Parity	One way in which external artefacts can aid cognition is by providing an explicit representation of the relationship between the current state and a goal state (Hutchins, 1996). The closer the representation is to the cognitive need or goal of the user, the more powerful

	that representation will be. As in ToT, the Operations Management could quickly see the level of action that was taken from a live regional map which showed active teams in operations. If a region has no markings, there are no active operations and vice versa (Fussell & Goodyear, 2017, p.170-171). Thus, a qlimpse of the situation can give immediate signal – like why is something not happening somewhere (p.172).
Coordination of Resources	Resources are described as abstract information structures that can be internally and externally coordinated to aid action and cognition by Wright et al. (2000). The six resources that they describe in their Resources Model are: plans, goals, affordance, history, action-effect, and current state. In the context of ToT, there are several artefacts that were used to coordinate resources. These ranged from local, physical artefacts like whiteboards (McCrystal et al., 2015, p.122) to the shared screens of the JOC (p.160-161), and most importantly to the daily virtual videoconference, the O&I (Fussell & Goodyear, 2017, p.165; McChrystal, 2015, p.227) However, reflecting on the six resources (Wright et al. 2000), the entire organization structure was served the purpose of coordinating resources through distributed cognition.
Social model	The social structure of an organization can be superimposed with a goal structure such that a subordinate can only stop when their superior determines that their goals have been met. In this manner, the goals filter down through a hierarchy with overlapping responsibility. This creates robustness in the system through group monitoring and job sharing, if necessary, to get the work done. It also means that the system can work through individuals whose main concerns are their local goals. (Hutchins, 1996, p. 203) The elements of a goal structure is based on the Aligning Narrative (Fussell & Goodyear, 2017), where the narrative entails the broader goal of the entire social structure to operate on.
Social Structure and Goal Structure	
Socially Distributed Properties of Cognition	The ''performance of cognitive tasks that exceed individual abilities is always shaped by a social organization of Distributed Cognition'' (Hutchins, 1996, p. 262). Two ways that social distribution can be organized to produce some cognitive effect include: (1) lots of overlap and the sharing of responsibilities for error checking and (2) separating communication channels to make sure that decisions are

	robust in checking that multiple independent sources agree. The social connectivity of ToT enables a direct and wide variety of teams and experts to collaborate on problems with natural overlap, but also by using the principle effectiveness of Small World (Gureckis & Goldstone, 2006; McCrystal, 2015, Fussell & Goodyear, 2017)
Social Circles of Privacy	A central concept in the analysis of an individual's social behavior and surroundings is the role of privacy as it relates to personal space, physical or digital (Altman, 1976). How and what we keep private in a social learning or working group may impact the way information is distributed within the group. In ToT, it was a challenge to break the "tribal" loyalties and distrust that prevented teams and partner organizations sharing information (McChrystal, 2015).
Social Emersion	Term "emersion" refers to the process of emerging, indicating something that appears after being out of sight. Therefore, the principle of Social Emersion represents the extent of how social roles emerge and impact the social structure and varies from group to group (Toseland & Rivas, 2005, p.108-109) and based on the workspace. In the ToT context, often subordinated were more experienced on a given situation than their superior, so they became de facto leaders in situations. This is highly related to the Empowered Execution that was driven in the Task Force (McChrystal, 2015, p.213).
Evolutionary model	The more interaction and experience a user have with a system, the better they perform in it as they become tightly coupled with the environment. Here, the processing loops in the functional cognitive system become tight, fast, and spontaneous (Hollan et al., 2000 p. 186). As the participants of O&I became more accustomed to the format, more lively discussion and information sharing started to form. This expanded with the use of chatrooms, when people started to get more expert with the system (Fussell & Goodyear, 2017).
Expert Coupling	
Cultural Heritage	Hutchins (1996, p. 169) extends the parable of an ant's movements scouring a beach. In this, we are asked to envisage a whole history of ants searching for food. After a time, the seemingly random behavior becomes more focused and directed as the later ants can go straight to the food source. In refraining from attributing, a greater intelligence to the later ants the changes that we have actually been

	observing to influence behavior has been the changing landscape as chemical trails have been left on the beach. Similarly, Hutchins argues people (in communities) have been left with an enriched landscape to support our behavior. In the case of ship navigation, the team has adopted maps, tools, strategies, and lessons all developed and laid down by previous generations. This forms part of our cultural heritage. In the case of ToT, the challenge was to overcome centuries of military hierarchical tradition, as well as tribalism of different units (McCrystal et al., 2015).
Semantics of Body	This principle is related to the embodiment of information in representations in the cognitive system (Zhang & Norman, 1994), and approaches the cognitive system with an attempt to map the evolution of an artifact within the artifact ecology and the associated roles and features it possesses over time, such how position of tablets and computers might affect the performance of the actors within it. The analysis of evolution on artefacts can be summarized with a more broad sentiment that the physical environment of ToT changed from silos and security-clearance based one (McChrystal et al., 2015, p.122 and p.156) into combining everyone under the same roof of JOC and aligning even the wall of screens so that everyone could see everything (McChrystal et al., 2015, 160-161).
Continuity	The aspect of continuity aids sense-making practices across time and space (Dror & Harnad, 2008). Establishing links between events, tasks, and materials supports group's coherence, and order over time (Jornet, 2014). Artifacts within ecology can, therefore, support cognitive thinking of the group and increase the links between activities of different individuals.
Mutual Adaptation	Schwartz and Martin (2006) identified that the degree of stability or adaptability of individuals and their environment impacts distributed cognition. Both people and their surroundings change form in the current context. Mutual adaptation or co-adaptation involves the co-evolution of the individual and the environment. The principle reflects how individuals discover or create niches within an artifact (or multi-device) ecology that allow them to co-adapt to the needs of the collaborative activities (Coughlan et al., 2012). As individuals adapt to their environment, they discover structures and patterns that ease the comple-

	tion of a given task. In the ToT context, a previously tool (secure videoconference) was used for communication, but it's purpose changed at first through the leaderships use and then followed by the adaptation of the users: more participation, cameras on, discussion rather than listening (Fussell & Goodyear, 2017, p.88-89; McChrystal, 2015, p.167).