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A Socio-Technical Regime Transitions Model for Gerontechnology Service Design: Privacy, Information Security and Cyber Security in Focus

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Abstract. In this paper, we present on ongoing research to use a socio-technical privacy, information security and cybersecurity model to support the design, development and delivery processes of health care services for aging in place. The current research in gerontechnological services development is reviewed, and experiences from the use of serious games to evaluate the model are outlined.

Keywords: Socio-technical, Gerontechnology, Aging in Place

Introduction

The purpose of this paper is to outline a socio-technical privacy, information security and cyber security system (ST-PICS) modeling approach to support gerontechnological service design, that aligns with a proactive health care strategy of "aging or living" in place. The model attempts to go back to the origins of socio-technical systems analysis and design practices which starts by examining the work systems as a first step [1]. Starting with the primary work system, the next step is to examine the organizational structure and then the macrosocial systems or domains [2].

Even though the socio-technical systems analysis approach starts by analyzing the work systems, it often starts by framing the problem from a macrosocial perspective first. At the macrosocial systems level, the United Nations has declared an aging population as a global problem and the decade from 2021/2030 the decade of Health Aging [3]. Even though the United Nations points out that "No single discipline, perspective or method will achieve these goals", Kolkowska et al. points out socio-technical issues are often ignored [4], and there is a strong technological determinism bias in current research efforts to deal with the health aging problem.

This paper is divided into 4 sections. After the introduction we outline terminology and concepts used to identify and frame the problem of health aging as a socio-technical regime transition issue. In this section we also briefly contextualize this paper as being part of a 4-year doctoral research project in applied socio-technical modeling, measuring, and managing of cyber crisis and cyber crisis prevention for the "civilian" sector in

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Norway. In the third part of the paper, we review some of the current research on applying socio-technical thinking and readiness measuring and modeling to manage socio-technical regimes. In the final section of the paper, we outline a preliminary research agenda for testing socio-technical readiness assessment tools with hybrid cyber range megagame called CS-Technopoly.

1. Framing the Aging Issue: Terms and Concepts

Gerontechnology is a combination of the two English words; gerontology and technology. Gerontology which can be defined as the study of physical and mental aspects of aging, as well as the social and societal implications of aging [5]. Technology has many definitions that have changed over time from being defined as "the useful art" to the use of science in industry [6]. Currently most gerontechnological research focus seems to be technological deterministic in nature and to a large extent are designed to support what Estes referred to as the "The Age Enterprises" which she defines as the

> "Congeries of programs, organizations, bureaucracies, interest groups, trade associations, providers industries and professional that serve the aged *in America.*"[7]

This technological deterministic marketplace frames "old age" as "the problem" and uses the rhetoric of management by crisis to ignore key issues, which Kenner outlines as

> "the inadequacy of the social systems as structural inequalities and power asymmetries reproduced by the commodification and biomedicalization of aging become quite visible when elderly care becomes an elderly crisis." [8]

There are those who acknowledge that gerontechnology approach is limiting and propose a new area of Socio-Gerontechnology [9]. However, it is the position of the authors that the current socio-technical "Age Enterprise" regime system model promotes technological determinism reactively and does not facilitate adequate socio-technical agency in the marketplace, in order provide sustainable products and services that meet all the stakeholder's needs, wants and desires.

There are several different socio-technical models and methods, and tools used to understand, explain, prevent, and even predict, events, incidents, and crises in socio-technical systems. Clegg et al. have proposed the PreMiSTS method to predict and prevent malfunctions in socio-technical systems (PreMiSTS) [10]. Al Sabbagh has proposed an STS framework to design a cyber security warning system and to perform threat analysis of software supply chains [11]. A.L. Cassano-Pichea used the Rasmussen risk management framework and the AcciMap tool to do an ex-post analysis of seven predictions regarding the bovine spongiform encephalopathy (BSE) epidemic [12]. As part of her 4-year doctoral research program, Østby is developing within a hybrid cyber range platform a socio-technical cyber security readiness assessment tool to support training and education of civilian organization to prevention and proactively manage cyber security crises that can occur with the introduction of digital technology into civil (non-military) societal services and products. This readiness assessment tool was designed using several different socio-technical models [13, 14].

In the gerontechnology research community, several "assessment templates" and tools have been proposed in general to assess customers and users. But as Cozza et al. points out

> "This nuanced uniformity is confirmed by the absence of explicit controversies between actors. Almost all the constructions see a trajectory of progress in which technology benefits all actors involved, and there is a general agreement in associating future ageing with an ever-increasing consumption of technology. In this sense, consumeristic ageing as well as technology-integrated ageing are the most explicit constructions. Positive effects of technology are projected both on caregivers − since it is expected that welfare technology reduces their working overload and time pressure − and, thus, on public sector organizations that are entitled to assess (i.e., civic ageing) and standardize (i.e., normalized ageing) welfare technology." [15]

This view, in combination with the notion of complex jobs, needs simple organizations as outlined by Walker et al. [16].

> "Henceforth, we will use the concept welfare technology to refer to technologies which are usually clustered according to supportive, responsive, or preventive functions (Beech & Roberts, 2008). Supportive technologies help individuals to perform tasks that they may find difficult to perform on their own (e.g., medicine reminder/dispenser). Responsive technologies, based on detection and reaction, help individuals to manage risks and raise alarms (e.g., personal emergency alarms). Preventive technologies based on prediction and intervention mitigate dangerous situations and raise alarm (e.g., key systems for home nursing)."

These views direct systems researchers' attention to what people do with technology in their everyday practices, and how such use is structured by the rules and resources implicated in their work, rather than trying to understand why and how a given technology is more or less likely to be appropriated in various circumstances. These practical views focus on knowledgeable human actions. It makes the systems researcher focus on how recurrent engagements with a given technology constitutes and reconstitutes emergent structures of using the technology (technologies-in-practice). Thus, the research orientation is inverted — from a focus on given technologies, embodied structures, and their influence on the worker — to a focus on human agency and the enactment of emergent structures in the use of technologies.

2. Review of Current Research

As presented by Vasunilashorn et al. in [17], there has been an increase of academic literature (research) about aging in place over the last years (especially from 2000 – 2010). The mentioned literature, however, contain "a variety of topics pertaining to aging in place, ranging from housing and environment to health and technology" [17]. More recent systematic literature review on aging in place and quality of life [18] also reveals that assessment on quality of life is seldom performed, and that there is no consensus on definitions or domains structures. Additionally, an overview of systematic reviews of home care vs alternative locations of care [19] found "that home interventions that promote elder health and independence might be effective in helping elders age at home". They were however not able to make recommendations on alternative locations of care.

By using The Quality of Life Group of the World Health Organization's (WHOQLG) definition of quality of life as ''individual's perception of his or her position in life in the context of the culture and value system where they live, and in relation to their goals, expectations, standards and concerns'' [20], Vanleerberghe et. al [18] suggests that

"Quality of life instruments for older people must be developed bottom up, with respect of the values and standards of the individuals of the population of our focus". This bottom up-suggestion is aligned with the early motivation of socio-technical research [21], to improve industry-workers stationary and repetitive job situation.

However, gerontechnology as described in the introduction has previously focused on "ready-made" technologies driven by tech-companies "meeting" the problems of the increasing number of elderlies in society [22] which not necessary are in line with the elderlies' expectations, standards and concerns. Thereby, "do-it-yourself" technologies have emerged, and elderlies see these as valuable alternatives, and purchase these from gerontechnology showrooms [22]. This can lead to troubles for the care-taker organizations and other care-takers to uphold knowledge and system-security and privacy requirements for all equipment involved [23], and to uphold check-lists [24]–[26] thar follow agreed standards. These check-list assessments are so unique that no template fits all needs, so they create their own by collecting as much data as they can and populate it into a sample report which looks different depending on the focus of the modifications.

These issues can be referred to as technological determinism as initiated by Veblen [27]. The socio-technical approach, however, would not exactly have a top-down approach needed to meet the challenges but more of an holistic approach which means that technology, should not be the dominating factor when new work systems are developed [21]. In the terms of aging in place and gerontechnology, we suggest that all parties should be involved in discussions on what to implement and how. This may be referred to as a social constructivism approach [28], which is working in projects to discuss and determine decisions appropriate to meet all involved stakeholders' needs, wants and desires. Often such initiatives have had the construct of a "paneling-board" which has a top-down assessment approach that is not appreciated by the elderlies and their next of kin. In this paper, we therefore suggest a combined bottom-up/top-down approach in a socio-technical escalation and de-escalation framework to meet the challenges.

Resent socio-technical research and studies [14, 29, 30] present escalation maturity models to assess the maturity of information security in organizations. These assessments are based on the ISACA framework [31], and the questions are modified for information security escalation risk assessment and treatment [32]. The escalation maturity model is presented in Figure 1.

Attribute / Level	1 Awareness	2 Responsibility	3 Reporting	4 Policies and standards	5 Knowledge and education	6 Procedures and tools
0 Non-existent						
1 Initial						
2 Repeatable						
3 Defined						
4 Managed						
5 Optimized						

Figure 1. Escalation maturity model [29]

We suggest that this model can be used in to model the aging in place issue, including management, formal and informal caregivers and the elderlies themselves. Additionally,

a modified version of Wahlgren & Kowalski's [33] escalation management model would work as a continuous risk assessment and risk treatment model in collaboration with the different stakeholders. The escalation management model is presented in Figure 2.

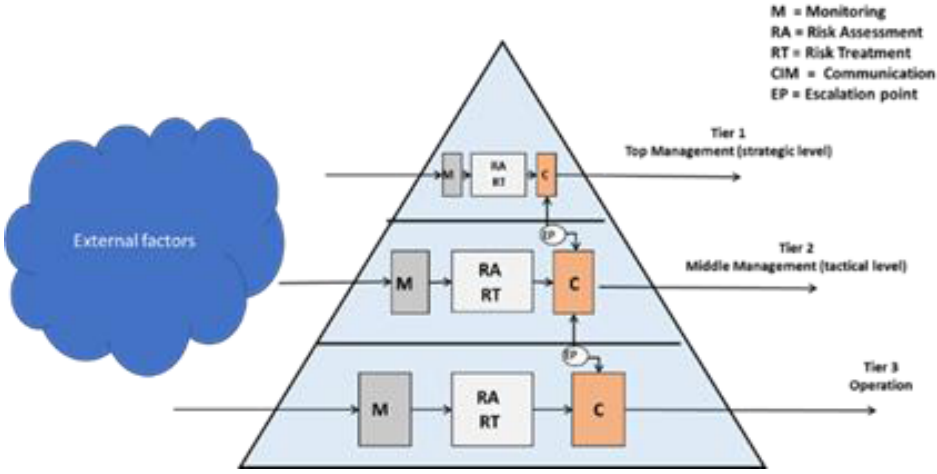

Figure 2. Escalation management model [33]

We suggest that the risk treatment as presented in Figure 2 is one of the core methods to meet the growing need for combining top-down and bottom-up approach in aging in place. Colnar et al. [34] suggests a risk mitigation model to meet the information security challenges in gerontechnology. The model is used to consider new appropriate risk mitigation measures in an appropriate time. In Østby et. al [14], a socio-technical maturity improvement process was suggested to enhance Colnar's risk mitigation model. This process is presented in Figure 3.

Figure 3. Maturity improvement – a socio-technical lesson learned approach [14]

We suggest that the risk treatment process in gerontechnology would have to be implemented in a similar process, to mitigate risk at various steps of quality-of-life standards due to individual's aging process. This can also be supported by risk matrixes [35], at the individual level, but also with other stakeholders who are involved in the delivery of care services.

The communication as presented in Figure 2 between the different aging in place stakeholders is important to meet the challenges. In a recent study, Nurgalieva et al. [36] have explored communication practices that tailor presentation of information to

improve the risk assessment of an elderly person fall injuries at home. This form of information sharing is comparable to crisis management escalation communication in SIEMS systems [37] and crisis management systems. We propose to transfer SIEMS and CIMS systems to support aging in place stakeholder communication.

In such communication-frameworks, organizational semiotics must be considered. Turoff et al. [38] present a dynamic emergency response management information system to improve information flow. However, as this is more a top-down approach, socio-technical semiotics as presented by Piccolo et al. [39] is better for considering information flow in the necessary communication. Many different stakeholders are involved, and a common set of semiotics is needed for the information flow to be effective and efficient. This can be managed by a social constructivist approach of FRISCO as presented in [40].

The doctoral research agenda is targeting societal structures and systems which should not exclude the societal implications of aging in place. The funding that would be necessary to integrate these two processes can come from national authorities (taxes) or from private initiatives. In a survey of program leaders representing 69 villages and 62 NORC programs in 2012, "key differences were found in the means through which villages vs NORC programs seek to achieve these aims (aging in place), as well as the populations likely to benefit from their efforts" [41]. Martens [42] conducted a similar analytical study of the Norwegian society. The study outlined funding responsibilities and presented how difficult it is to measure national and communal responsibilities for aging in place improvements.

> "The Norwegian national government states that housing is an individual responsibility [25, p.7]. As many people as possible should live in their own homes and receive necessary home-care services there, and as many as possible should live in ordinary housing in ordinary surroundings with the possibility of living independent and active lives [41]. In the municipalities, the allocation of responsibility for housing is less explicit: Only 1 in 10 care plans and 3 in 10 housing plans state that housing is an individual responsibility. Among the municipalities that make this statement, several express the responsibility in very vague terms. This difference in how individual responsibility is emphasized can lead to different approaches to aging in place policies." [42]

Socio-technical theories, however, suggest that socio-technical analysis should be done on each layer in society [28]. This theory could be an extension of the suggested escalation/de-escalation model. This would enable us to model who should be accountable for funding and improving aging in place. We consider dynamic socio-technical approaches like Leavitt [43], Kowalski [44] and Davis [45] as the foundation for socio-technical considerations for each stakeholder involved. The Kowalski model, which includes typical stakeholders, is presented in Figure 4.

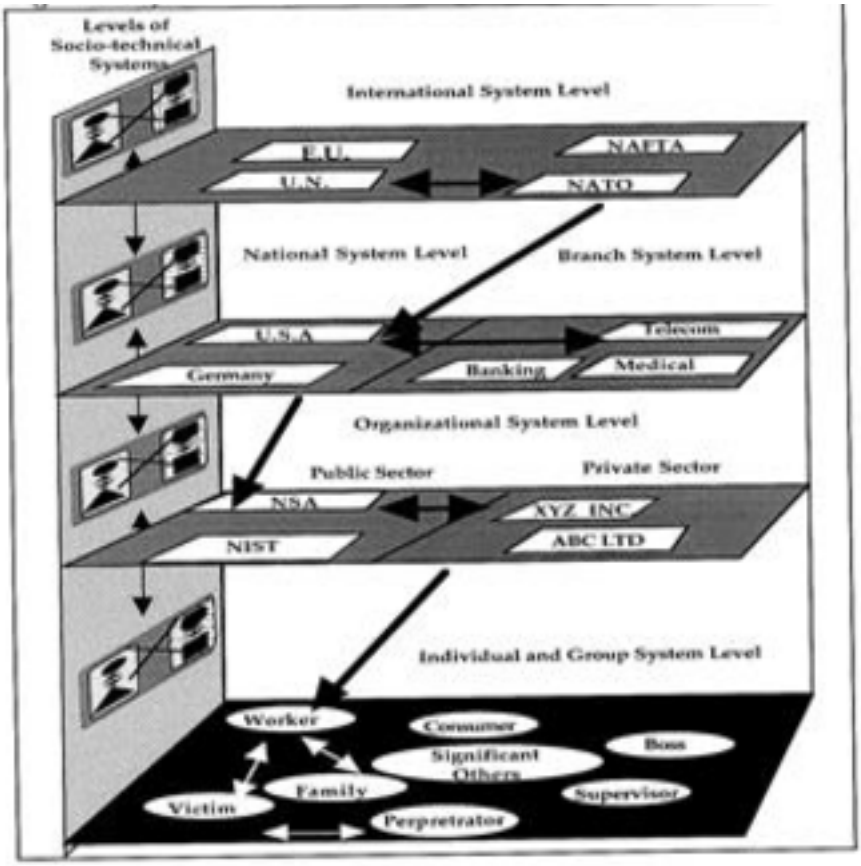

Figure 4. System of Socio-technical Systems [42]

To measure the societal readiness, one may use readiness-levels as presented by the Innovation fund in Denmark [46] in combination with risk management [47]. In other words, combining the level of readiness with the level of risk to outline socio-technical measures to improve aging in place for the system in focus [14].

3. On-Going and Future Research

To push for a more social constructivist approach and move away from a gerontechnological service design process that is less technological deterministic, we are developing and testing different serious games and exercises in the Norwegian Cyber Range. In these serious games and exercises, different stakeholders can play different roles based on specific experiences and experiment with discussions and negotiations [48] of how to move from one socio-technical regime to a new one.

For a classroom exercise, we extended the work done on socio-technical transitions canvases by Van Risjnsoever and Leendertse [49] and integrated it with the Kowalski security model [44]. In this exercise, we have information security master students performing a socio-technical analysis of a brain computer interface patent BCI [50] for

a long-term care facility that wants to use these interfaces to support health care delivery to their residents [51]. The students are tasked to identify socio-technical gaps in the systems and then required to debate if the brain computer interface health benefits outweigh privacy, information security and cybersecurity risk that this new brain computer interface creates. In the debate, the students are assigned different roles where one group of students represents long care facility service provider who is suggesting the introduction of the brain computer interface device to improve care, and the other the residents' council in the long care facility who is against the introduction of the brain computer interface device. Preliminary data collected from students on similar exercises [52] has shown favorable results. However, more longitudinal data is needed to evaluate the learning outcomes.

Megagames have been used in the health care sector to support stakeholders in their discussions on complex issues in health care service delivery [53]. We are currently developing and have beta-tested a megagame called CS-Technopoly [54]. The megagame is designed to model cybersecurity in society from a socio-technical perspective in general and will include the possibility to simulate and gamify the issue of aging in place so that stakeholders can have the opportunity to practice the negotiation of gerontechnology service design.

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