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# Internet of Things (IoT) enabled assistive care services: Designing for value and trust

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## Abstract

The rising elderly demographic, often with long-term conditions, represents a significant challenge globally in terms of planning for the efficient use of increasingly expensive and constrained health care resources. The internet of things (IoT) emerged as a disruptive and transformative new technology that could potentially stimulate development of new innovative assisted living health and care services. In this paper, we argue that as the human agency and relationship intrinsically associated with care get transferred to the material agency of smart technology, value and trust should be a vital consideration for designing such services. Drawing on interdisciplinary perspectives from the literature on services innovation, design science and trust in relation to healthcare technologies, we present a conceptual framework that articulates various levels of trust among the concerned stakeholders in the service ecosystem and suggests value-sensitive design considerations, anchored on the principles of trust, for future IoT-enabled assistive care services.

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*Keywords:* Internet of Things; IoT; Service design; Assistive care; Design for trust; Value-based design, Telecare, Telehealth

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## 1. Introduction

Between 2015 and 2050, the proportion of the world's population over 60 years will nearly double from 12% to 22% and all countries over the world face major challenges in addressing the health and care demands arising out of this demographic shift<sup>1</sup>. To illustrate the magnitude of the problem, the budget deficit for the UK National Health Service (NHS) is expected to reach about £30 billion by 2020/21<sup>2</sup>. This has created a drive to develop new strategies

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for more efficient healthcare service delivery – especially focused on the provision of digital technology enabled assisted living care services such as telehealth and telecare. The key business driver for such services is the ‘preventative’ role of technology where services can be delivered for elderly and/or vulnerable people with long term conditions such as diabetes, COPD, dementia etc., outside the clinical settings, augmenting existing ‘face to face’ care, and supporting independent living at home, self-care and well-being.

The *Internet of Things*<sup>3</sup> (IoT) emerged as a disruptive and transformative new technology<sup>4</sup>, and attracted significant attention from academics, practitioners, and policy makers. According to industry forecasts, the number of networked devices will reach 25 billion by 2020<sup>5</sup>. The huge volume of data and information generated through IoT has potential to revolutionise and create market space for new products, service offerings and business models. Among various sectors, healthcare sector is forecasted to have the biggest growth potential out of IoT business– in the tune of \$2.5 trillion annually by 2025 and care for chronic conditions through remote monitoring by new ‘smart’ technologies will be a key application area<sup>6</sup>. Amid all the hype around opportunities and promises of IoT services, the socioeconomic perspectives – in particular the value of healthcare technology design that effectively connects with the emotional, social and physical needs of the end user remain vital<sup>7</sup>. The high degree of automation, interconnectivity and transfer of sensitive private data involved in such services raise ethical questions underpinning security and privacy concerns<sup>8</sup>. In this paper, we argue that as the agency of human and relationship intrinsically linked with care services get transferred to the material agency of IoT based ‘smart’ technology, ethical and moral aspects (including notions of privacy, trust, resilience and societal goals) need to be vital considerations for designing such services.

This paper begins with a brief discussion on value-laden aspects, including trust associated with the digital technology enabled assisted living health and care (Telehealth / Telecare) services. This is followed by a short review of the service and design literature with particular focus on the conceptualisations of value in service-dominant logic and design thinking related the concept of value. In the next section, we present a conceptual framework linking various levels of trust with the value co-creation in the service design. Finally, we conclude by articulating the key implications of trust-based design for IoT-enabled care services and by reiterating the need for future research in this direction.

## 2. Literature review

### 2.1. Assistive care services: Concerns around trust

A review of digital healthcare literature suggests that a considerable amount of tension exists between the two discourses – one articulating technology-deterministic (often referred as ‘techno-utopian’) views on the potentials and opportunities of digital technologies while the other providing critical perspectives on the broader social, cultural and political dimensions, around the issues of ethics, surveillance and the passivity of the remote care<sup>9, 10</sup>. Digital technology based remote care solutions such as telehealth and telecare involve ‘de-territorialisation’ of the physical structure of the institutional and community care settings<sup>11</sup> and can socially alienate users of such services<sup>12, 13</sup>. Accordingly, scholars advocate a critical need for examining the moral context of the use of digital technology in evaluating its effectiveness<sup>14</sup>. Trust is cited as a critical component of the relationships, - between the user and the mediating technology and between the user and the providers for assisted living care services<sup>15</sup>. Lack of trust can be attributed to the exclusion of the users from the service design choices – making the engagement with technology difficult<sup>16</sup>. While ‘human centred’ design considerations attempt to address the challenges, the perspectives are limited to the functional usability and user experience at the interactional level with the technology devices<sup>17, 18</sup>.

Our ongoing research project exploring the adoption of telehealth and telecare (telehealthcare) technologies and future designs of related service business models highlights the key role of organisational relationships and collaborations in creating value across the service ecosystem<sup>19</sup>. Initial findings from our study suggest that full potential for current telehealthcare systems is yet to be realised in absence of the capacity and efficiency of digital

IP-based solutions. IoT-enabled technologies - using ‘smart’ sensors, low power operation and wireless networks (such as 5G) present huge opportunities for innovative care service designs and integration with other digital solutions such as ‘smart home’. A shift or upgrade to such solutions imply higher automation, with reduced or eliminated need for human intervention in collection and processing of health and care information. As the relationships between the enabling technologies and the service users are reshaped this way, an important question arises - how could we design technology services that are more trustworthy<sup>20</sup>? While the issue of trust for digital technology has been discussed in the literature mostly around trustworthy digital infrastructures such as the Public Key Infrastructure<sup>21</sup> or “system-like trust” constructs<sup>22</sup> (e.g. reliability and functionality), the relational aspects of technology, particularly in relation to the role of trust in service design and value co-creation are scarcely mentioned.

## *2.2. Value co-creation: Perspectives from service science and innovation research*

Value is one of the most ill-defined and elusive concepts in the academic literature<sup>23</sup>. In the service management and innovation literature, service-dominant logic<sup>24, 25</sup> (SDL) has emerged as the leading research approach with a conceptualisation of service that is customer-centric, interactional and relational in nature. SDL argues that value is always co-created in a service exchange, jointly and reciprocally, and that “there is no value until an offering is used – experience and perception are essential to value determination”<sup>26</sup>. Internet of things involves a complex ecosystem comprised of diverse set of actors, technology standards and protocols<sup>27</sup>. Accordingly, an IoT-enabled service entails co-creation of value by economic and social actors within a value constellation<sup>28</sup> or service system<sup>29</sup>. Information and communication technology (ICT) plays a major role in service innovation<sup>30</sup> and provides transformative opportunities to the services industries<sup>31</sup>. For IoT-enabled care services, technology remains a key component of the service systems in creating value-co-creation configurations of people, value propositions, and shared information<sup>32</sup>.

Drawing similarities and dissimilarities between healthcare and other services, many scholars highlight healthcare as one of the most complex and challenging sectors with high impact on economies and quality of living<sup>33</sup> and advocate a strong future research agenda for the service. The themes of patient engagement (also referred as ‘participation’ or ‘involvement’) and empowerment have drawn increasing attention in the academic literature<sup>34, 35</sup> and policy discourses, with advocacy around ‘patient-centric care’ service design<sup>36</sup>. Such user centricity is in alignment with the transformative goal for healthcare services and linked with the potential of co-production and co-creation of value between the care service providers and users / beneficiaries<sup>37, 38</sup>. A limited volume of empirical studies has attempted to explore the value co-creation or co-production in various health and care settings<sup>39, 40, 41</sup>. Although the notion of consumer value co-creation in healthcare is a nascent phenomenon, the implications for healthcare service organisations could be significant<sup>45</sup>.

## *2.3. Value perspectives from design research in service context*

Scholars identify the area of service design as a research priority<sup>42</sup> and highlight the need for an interdisciplinary approach since service design is closely intertwined with the business strategy, operations and the service business model<sup>43</sup>. While value as a standalone concept is scarcely discussed in design literature, the purpose of design to deliver clear, meaningful and effective solutions to serve users’ needs connect with the concept of value-in-context in SDL<sup>44</sup>. The human-centred, experiential and participatory ethos of design thinking provides value relations between diverse actors within a socio-material configuration<sup>45</sup> and provides complementarity to the studies of services science, management and engineering<sup>44, 46</sup>. In the design literature, there is an increased interest on the integration of ethical and moral values into the design of technologies, primarily information and communication technologies and the discourse manifests in a paradigm of ‘value-sensitive design’ (VSD)<sup>47</sup>. Trust being a high-level value demands due attention in value-sensitive design considerations for ICT systems<sup>48, 49</sup>. However, scholars recognise the distinctive and problematic nature of the trust in technology as the debates encompass the issues of trust in digital artefacts and systems as well as the interrelationship between trust, technology and design<sup>50, 22</sup>. Technology is “humanity at work” and trusting technology is fundamentally trusting the people who are creators or implementers of the technology<sup>51</sup>. Therefore, an important question arises: what is the potential role of trust in

design of technology intensive services, such as IoT-enabled care services? We draw inspiration from a model of trust in relationships prevailing in the economic and public domain – proposed by Lewicki and Bunker<sup>52</sup> and propose a conceptual framework of trust based design for the health and care services in the next section.

### 3. Healthcare services: A model for trust-based design

Trust is defined as “a state involving confident positive expectations about another’s motives with respect to oneself in situations entailing risk”<sup>53</sup>. In the context of service design, trust is an institutional phenomenon, which needs to be differentiated from the trust in personal relationships. An influential study exploring the issue of trust in organisational relationships<sup>52</sup> proposes three progressive and accumulative stages of trust in a relationship: calculus-based trust, knowledge-based trust and identification-based trust. The lowest level in the ladder, calculus-based trust typically applies at transactional level with considerations to the costs of deterrence or benefits from a relationship. The next level, knowledge-based trust relies on information and predictability that instils a sense of mutual expectation on the likely behaviour of each actor in a relationship. Finally, the highest level in the hierarchy, identification-based trust prevails when the parties could identify each other’s desires and intentions, thereby acting one on behalf of the other. It is important to note that these three stages are sequential and build over one another with some overlap happening across stages.

Following our definition of trust, we argue that users’ trust in digital case services is interrelated to the expectation about the possible motives of the service provider in delivering the service. At the most basic level, the users are concerned about the safety and reliability of the service and the opinion about the service hovers around the perceived risks and potential benefits from the experience. The interaction is primarily ‘transactional’ by nature and confidence in the value of the service provides the foundation for trust between the user and the provider. The levels of trust are progressive as they are shaped by repeated interactional experiences from service exchange, accumulated over a period. The levels of trust builds as the interactions between providers and users shift from ‘transactional’ to ‘relational’ trajectory. We envisage a changing role for service design in pursuit of value-creating systems<sup>54</sup> and ground our design consideration on the principles of trust (see Figure 1).

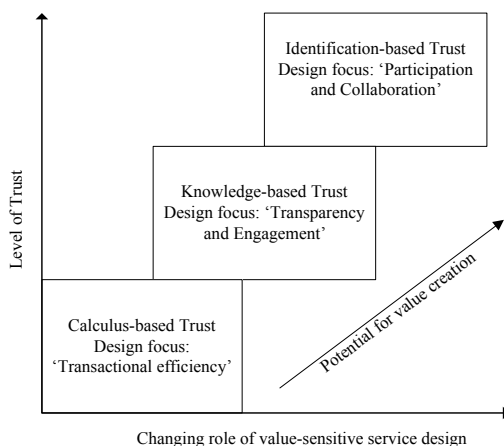


Figure 1. The changing role of value-sensitive service design as levels of trust evolve (Adapted from Lewicki and Bunker, 1995)

We identify three levels of service design approaches depending on the target trust level and outline implications of these approaches on the value co-creation opportunities in the service context (Table 1). Our framework proposes that the service design focus needs to shift from transactional efficiency to collaborative partnership in order to exploit value co-creation opportunities as the trust level evolves. We are investigating the utility of this framework for the design and adoption of sustainable telehealthcare services in a local city level context, as part of our work-in-progress research project. The prospect of an upgrade from basic analogue to digital broadband network technology

infrastructure / service provision, aiming to harness the higher potential of IoT technologies is on the horizon. This creates opportunities for linking the telehealthcare services with the concepts of ‘smart home’ and ‘smart living’, to enhance health, lifestyle and well-being of citizens. Under such changing landscape for service design, our framework gains relevance.

Table 1. Design focus for service value co-creation at various levels of trust

Design focus	Trust level and basis	Implications for service value co-creation
Transaction efficiency	Calculus-based trust based on consistency of behaviour in the service transactions	This is the minimal level of trust that needs to be present for successful service exchange. Provider needs to share relevant information to the risk-averse users to instill confidence in the adopting and continuing with the service.
Transparency and engagement	Knowledge-based trust that ensures predictability of behaviour or actions of the provider in various contexts	Bringing transparency to business practices particularly in relation to maintaining the reliability of service and safeguarding the privacy concerns of the users. This level of trust address the issue of risk aversion and lead to higher user engagement with the service.
Participation and collaboration	Identification-based trust that espouses mutual understanding and shared goals	Reflecting organisational identity and focus on social mission in delivering value for the users of the service. The explicit commitment to social responsibility of could develop the highest level of trust- driving potential opportunities for co-design / co-production with the users.

#### 4. Conclusion

The internet of things emerged as a disruptive and transformative technology that could potentially fuel innovative designs of ‘smart’ services in the assisted living and care domain. However, the high degree of automation, interconnectivity and transfer of sensitive private data involved in such services raise ethical questions underpinning security and privacy concerns. In this paper, we argue that trust-based service design could alleviate some of these ethical issues and engender better adoption of technology. We draw interdisciplinary perspectives from the literature on services innovation, design science, value and trust in relation to technology in presenting a conceptual framework that articulates a few value-sensitive design considerations anchored on the principles of trust, for future assistive care services. We hope that the conceptual framework serves as a useful investigative framework for empirical studies examining the role of trust in designing digital care services, with particular focus on the potential for value co-creation with service users. In this paper, our discussion has been limited to the dyadic relation between the service provider and the service user. In a service ecosystem, future research can elucidate the dynamics of trust-based relationships, and their implications for the value generated at a network level.

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