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Harnessing the Digital Records of Everyday Things

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Abstract:
We address how, framed by the Internet of Things, digitally-enabled physical objects may acquire rich digital records throughout their lifetimes, and how these might enhance their value, meaning and utility. We reflect on emerging findings from two case studies, one focusing on wargaming miniatures and the other on an augmented guitar, that engage communities of practice in capturing and utilising rich digital records of things. We articulate an agenda for future research in terms of four key themes: How can the digital records of everyday things be captured using both manual and automated approaches? How can these records enhance the embodied use of things in suitably discrete ways? How can people generate diverse stories and accounts from these records? How can we revisit current notions of ownership to reflect a more fluid sense of custodianship? The findings of the studies reveal common emergent themes and preferences of the practicing communities that surround these objects and the above questions, while ongoing participatory and probe studies continue to reveal nuances and evaluate possible approaches.

Keywords: Internet of Things, Objects, Records, Footprints

1. Introduction

The notion of the Internet of Things (IoT) envisions a future in which we are surrounded by digitally-enhanced and inter-connected physical artefacts (Atzori et al., 2012). The IoT has recently become the focus of both intensive academic (Barthel et al., 2013) and commercial (Turber et al., 2014) research and investigation, ranging from new technical capabilities to potential impact on our everyday lives (Fritsch et al., 2011).

One implication of the IoT vision is that these future 'things' will be capable of capturing extensive information about their on-going use. Regardless of the technology employed, the singularisation of objects through unique identification (Koshizuka & Sakamura, 2010) combined with the ability to communicate with both internal and external sensors,

inevitably leads to the possibility of everyday things acquiring rich and extensive digital records over their lifetimes (Karpovich, 2011).

The recording the histories of things is not a new phenomenon. Physical artefacts are often documented as being of interest and wonder, whether through personal meaning such as in the case of heirlooms or mementos, or on a broader social level, with cultural artefacts. The resulting records enable us to tell stories about and through these things, ranging from personal, family and social stories to meticulously researched accounts of provenance by the curators of museums and galleries.

However, digital technologies bring the potential to greatly amplify and thereby radically transform such traditional practices (Ahmed et al., 2012; Flintham et al., 2015; Fosh et al., 2013). The digital footprints of things in the future IoT may be far richer, pervasive and persistent than traditional forms of documentation. Indeed, it could well be that the entire existence of future things, from their manufacture through to everyday use by various owners, to ultimate obsolescence, might be charted and examined, or even re-experienced. While this scenario may appear far-fetched, there are already several projects that have been exploring the rich digital footprints, for example Tales of Things (de Jode et al., 2011), and Significant Objects (Glenn & Walker, 2012), as well as various examples of tracked objects such as Book Crossing (Eidenbenz et al., 2013) and Where's George (Brockmann & Theis, 2008; Shlesinger, 2006).

The emergence of things with rich lifelong digital records may give rise to new opportunities for enhancing their value, meaning and ongoing use. It also raises new challenges about what this data reveals about their users and consequently how it is owned and shared among them. With the above in mind we set out to explore two key issues. The first was to understand how 'things' may acquire rich digital records over their lifetimes, meaning that we sought to understand how and why such records are created, maintained and shared. The second was then explore how we might harness these records to enhance the use, meaning and value of these things.

We report on two ongoing studies that explore how two quite different kinds of 'things' – wargaming miniatures and acoustic guitars – can acquire rich digital records over their lifetimes and how these might be put to use. Our particular contribution in this paper is to synthesise perspectives across two previously separately reported studies so as to draw out key themes that need to be addressed by future IoT research.

2. Case Studies

In choosing objects to study we were faced with several challenges. First, our chosen objects would need to have sufficiently complex lives, engaging in diverse interesting activities worthy of detailed record keeping. Secondly, we wished to adopt a lifelong perspective, meaning that we wished to follow such objects from initial creation through phases of active use, changes of ownership and even into ultimate obsolescence.

Our response was twofold. First, we choose our 'things' carefully – for example things with active but relatively rapidly unfolding lives. Second, we aimed to find ways of engaging the communities of practice surrounding these, by both bringing them into the process and supporting their existing practices of provenance and record keeping and presentation.

3. First case study: Wargaming miniatures

With the above in mind, our initial search for a suitable type of object led us to consider Wargaming Miniatures, specifically the miniatures involved in Games Workshop's well-known Warhammer 40,000 franchise (Carter et al., 2014).

These objects display a number of properties that lend themselves admirably to the purposes of the research. First, they are – as physical objects – the product of an extensive crafting process where they are built and hand-painted. Next, the models are tangible representations of narrative elements, as they are based in an extensive fictional background, perpetuated over multiple media such as novels and digital games, were hobbyists draw inspiration from their favourite characters and settings. Parallel to this, they are also tangible aspects of game mechanics, as they are used during gameplay with their 'tabletop' capabilities dictated by complex rulesets. This evokes further meaning from their users. The miniatures, or models, appeared to be considered by their practising community as representations of specific identities, skills, abilities, experiences and even separate viewpoints. Initial observations showed the community commonly perceived the models in such ways and went to great efforts to record, maintain and share their provenance and exploits. Models were observed to be sold with accompanying provenance records, which had the apparent effect of boosting their value, both financially and meaningfully.

At this point it was deemed appropriate to perform a deeper ethnographic study of Miniature Wargaming, and the Warhammer 40,000 franchise in particular, to confirm the above suppositions and identify the extent of these provenance practices, the techniques used and the apparent effects they had on the relationship of the hobbyists with the models. The findings of this study where subsequently published in (Darzentas, Brown, Flintham, & Benford, 2015).

In summary, the initial observations that led to the choice of this domain were validated and expanded upon. Three general stages in a miniature's 'lifetime' were identified, crafting, active use in gaming, and display.

The community was found to put great effort in charting and recording the crafting process of their miniatures, keeping journals and documentation and creating blogs to share them with the rest of the community. These included both practical information such as modelling and painting techniques but also more creative content such as backstories and interpretations of how their models would fit into the wider narrative background of the setting, a practice that was directly encouraged by the community.

These efforts continued in the gameplay phase. A common practice among the hobbyists was the creation and sharing of 'battle reports'. These were textual or video recounts of games using the miniatures. As with the crafting stage records, the reasoning and methods varied widely. Some hobbyists were more interested in creative narrative accounts of their games, while others used the battle reports as a method to analyse and develop their gameplay tactics and strategies. These are a common topic of discussion within the wargaming community, with the verdicts dictating the popularity, in of certain models, armies and strategies.

Finally, the methods that the hobbyists use to display their collections were also considered. As objects of both creative and competitive practices, the models are more often than not considered as prized possessions that the community strives to present and display. On a community level, the models are often the subject of painting and display competitions, were they are arranged in thematic dioramas that present their army and its achievements in some way, as seen in Figure 1 below.

Figure 1 (Left) Typical wargaming miniatures. (Right) Example of an army display board.

The ethnography concluded with a detailed breakdown of the community provenance recording and sharing practices for each stage, and thorough discussion of the emergent themes.

- First, the complexity of the model's 'life' was detailed, highlighting the difficulty of charting it. The non-linear nature of the object's lifetime, meant that conforming to a model would be impractical, and that a deep understanding of the context was needed in any effort of capturing records.
- Next, the methods and types of records were discussed, focusing on how these could be unobtrusively supported with IoT focused approaches.
- Finally, a case was made for the modification and application of the Trajectories framework (Benford et al., 2009) to support the curation of the records.

In keeping with the overall aim of investigating the impact of object's digital footprints, it was determined that the next step would be perform a series of participatory design workshops with experienced gamers in order to design and develop a set of interventions that would support the existing practices of the community, thus introducing IoT paradigms and capabilities to the miniatures but without compromising the core nature of the activity. This final point was considered vital as it was a common theme that emerged from the ethnography, in that the hobbyists, while unanimously open to the idea of technological support and augmentation of the hobby, were wary of altering the core of the hobby.

The Participatory Design workshops led to a number of prototype devices and services, as well as to a number of findings that influence the design of systems that enable the capture, curation and presentation of an object's physical footprint. Among the prototypes were general enabling technologies such as singularising tags, using NFC, and a back-end database and curation service in the form of a website where users could manage and share the content of their object's footprint. The content was actively and passively created by a number of prototypes and designs which included a photobooth device which captured the creation of a miniature, a time-lapse camera setup that captured gameplay and Augmented Reality display boards that enabled thematic viewing of the footprint content.

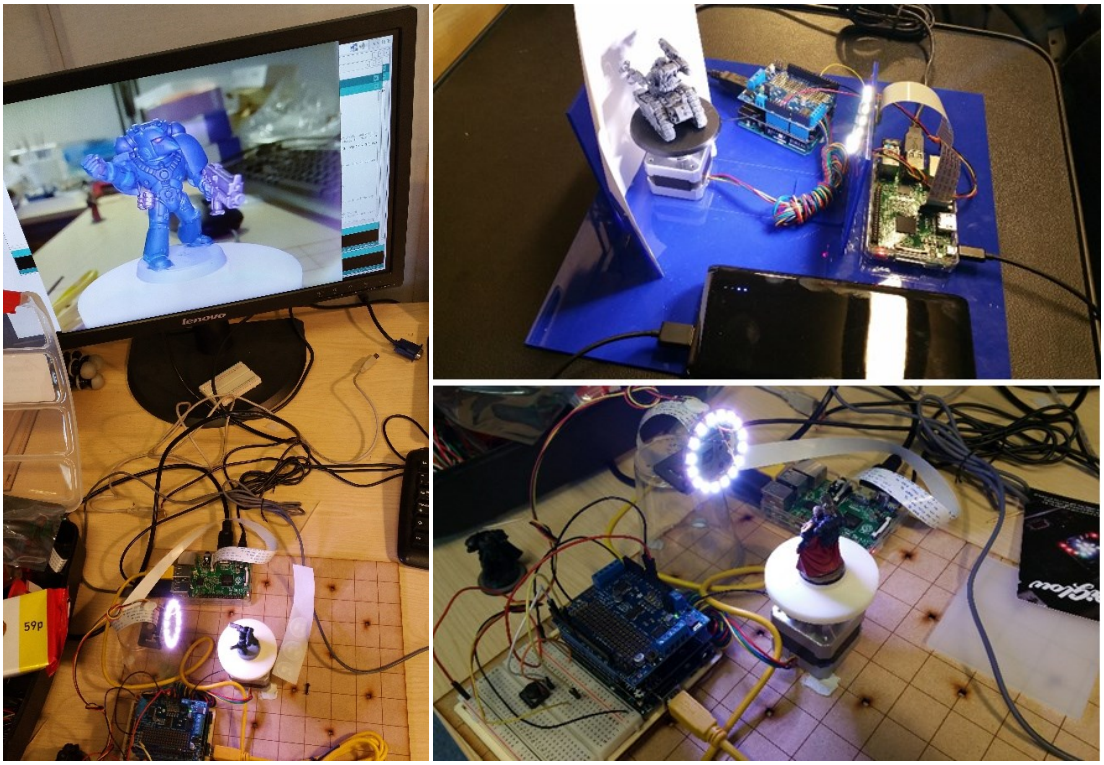

Figure 2 Examples of the capture devices that were developed during the Participatory Design workshops.

The generalizable findings included identifying the tensions between the requirements of the users in relation to the complexity of the footprint, the invisibility of the technology and the desire for information. Additionally, it was found that participants had a tendency and

preference, to treat and perceive some of their models as groupings instead of individually. These was found to be primarily for contextual reasons.

4. Second case study: an acoustic guitar

Our second case study involved creating a distinctive travelling technology probe, a digitally augmented 'thing' that could be released into the wild to tour through various settings so as to gather data and engage users in an unfolding design conversation. We chose to digitally augment an acoustic guitar to create an object that would be familiar to many people, valuable, readily portable and that might also gather rich stories through use. We imbued our instrument with a distinct identity in order to establish its uniqueness, naming it 'Carolan' in honour the 18th century Irish harpist and nomadic bard Turlough O'Carolan

Figure 3: The Carolan guitar

We engaged a graphic designer to create a series of six interactive Celtic knot work designs using the Artcodes technology (Meese et al., 2013). These function almost exactly like QR-codes, but are more aesthetically appealing - or beautiful. The patterns can be scanned with

a mobile device to conjure up digital information, in this case media from our guitar's digital record. We then collaborated with a professional luthier (instrument maker) to design and hand-build a bespoke acoustic guitar, including inlaying these six designs into different parts of its body – the headstock, fretboard, front soundboard, back, top and in a small nook at the cutaway – as shown in Figure 4.

Figure 4: Scanning the Carolan's soundhole

The second phase was to release Carolan into the wild, building up its digital record as it travelled. Our aim was to engage a diverse set of stakeholders in an inspirational design conversation, jointly exploring the nature and potential value of the guitar's digital record through a deliberately broad series of encounters in diverse settings. We followed a snowballing approach to recruitment, initially drawing on our own contacts with local players, venues and shops but then quickly reaching out through their contacts to engage people further afield, ultimately internationally. We progressed from early engagements where we accompanied Carolan on its travels so as to field-test the probe and seed its initial record to loaning the instrument for weeks at a time. Participants were encouraged to use the guitar as they wished. We then rapidly responded to their design ideas by reconfiguring our app. Participants and researchers jointly documented Carolan's history throughout its travels, capturing a corpus of photos, recordings, notes and interviews and drawing on these to create a series of blogposts (on carolanguitar.com).

We recorded Carolan's design and construction process through documentation ranging from initial design documents, to extensive photographs from the luthier's workshop, to a

video of the luthier playing its first ever song. A detailed account of the design can be found in (Benford et al., 2016). We also created an extensive user guide and technical specification that listed the fine details of the guitar's interactive features and construction and these were subsequently updated as a result of various technical set-ups, repairs and routine maintenance occurred, similar to a service log.

The results of this process can be viewed at Carolan's blog at www.carolanguitar.com and a detailed account can be found in the published paper (Benford et al., 2016). The following briefly summarises the key findings.

Initial outings were strongly shepherded, with us accompanying the guitar on short visits with a view to quickly seeding its digital record with engaging materials. We encountered several professional performers as they were touring, introducing them to the guitar and recording interviews in which they reflected on their own instruments and also recorded some songs and tunes, with one being so kind as to introduce and play the guitar during his live show. Subsequent engagements were less shepherded, with the guitar staying in players' homes, typically for a week at a time. Our hosts typically used the instrument as part of their everyday guitar activities including lessons, practice, composing new material and attending clubs and sessions. They captured photographs and videos that were added to Carolan's growing digital record along with material from interviews that we recorded.

We also staged a series of events to explore other activities that might contribute to and also draw on Carolan's digital record, including an open mic session, two recording sessions and a road trip overseas during which our guitar experienced the stresses of international travel. This last engagement provided an opportunity to experiment with deploying additional sensors inside the guitar including an accelerometers and GPS receiver to measure movements, temperature sensors, and an automatic camera placed inside the instrument looking out so as to record a guitar's eye view of the world.

This process of technology probing yielded key insights into the nature and uses of Carolan's digital record. The first concerned the richness of Carolan's digital record that quickly grew to encompass historical provenance; personal and public archives of performances and compositions; guitar stories inspired by Carolan; a user guide including playing and recording tips; a technical specification and maintenance log; playlists to be called up during live shows; materials for lessons; and records of movements and environmental conditions during transportation and storage.

Carolan's digital record added value and meaning to the guitar in diverse ways. One was to enhance its direct use, for example by providing tips on how to best record its voice or by recalling accompanying parts during practice. A second was to enhance its provenance by extending traditionally sparse provenance records with rich details of who had owned, played and maintained it. A third was to inspire players to create meaningful compositions and stories to be associated with the instrument. Finally, the digital record became the nub

of a social network of people who were associated with the instrument in different ways and who wished to follow its progress as it travelled to meet new players.

Recognition of potentially diverse uses for the digital record revealed a requirement to support complex and dynamic mappings between the instrument and its associated digital media. Thus, each person who borrowed or played Carolan r might require a personalized experience such that scanning its various patterns would connect them to those parts of its digital record that reflected their own interests or history. These mappings might then become dynamic, varying according to the times and locations of particular events (the guitar might conjure up different playlists of tunes at different sessions or gigs). Moreover, each such mapping – for a particular person at a particular event – might also address different audiences, for example delivering specific information to the current player and different information to any audience members that scanned it.

We therefore extended Carolan's software to allow users to create, modify and share personal and event specific mappings between the physical instrument and its digital record. While in principle, any of the six interactive surfaces of the guitar might be mapped to any information from the digital record, a convention gradually emerged in which specific surfaces tended to be reserved for particular purposes. Three surfaces became relatively fixed in their associations. The headstock (traditionally the site of the maker's logo on a guitar) tended to remain connected to official provenance information. The top sound hole (mostly visible to the player) tended to be reserved for the user guide. The fret board code that could only be scanned when the strings were removed was reserved for the technical specification and maintenance log. The remaining three surfaces were employed more flexibly. The front was often seen as public voice of the instrument to be associated with personal and event specific playlists, the small code in the cutaway was reserved for bonus material that rewarded close inspection, while in contrast the back offered a general purpose surface that could be scanned from several meters away. Thus, we learned that the mappings between interactive decorated physical things and their records are complex, multi-purpose, address diverse audiences, depend on the physical affordances (visibility, access and cultural meanings) (Norman, 1999) of their different surfaces and need to be dynamically tunable to different owners and contexts.

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3. Discussion

We now draw on our two studies to identify common issues and challenges concerning the design of future practices and enabling technologies for connecting everyday things with digital records so as to enhance their use, meaning and hence value. We group these under four broad themes concerned with:

- how humans and sensing technologies combine to capture rich digital records of things;
- how these records can be drawn on in suitably discrete ways to enhance the situated use of things;
- how they can also support the telling of diverse stories, from verifiable accounts of provenance to fictional narratives;
- and finally how we need to extend simplistic notions of ownership to cope with more complex natures of custodianship in which different stakeholders assume rights and responsibilities for the digital record over a thing's lifetime.

5.1 Capturing the Record

Our studies reveal that the digital records of things can be rich and complex, comprising various forms of data from sensor data logs such as GPS positions and environmental sensors, to records of people's interactions, to multimedia documentation of both creation and use. Thus a wargaming miniature becomes associated with extensive documentation of its construction and painting as well as statistics arising from gameplay and a guitar becomes associated with documentation of performances but also streams of sensor data about temperature and movements.

The capture and curation of such a complex digital record demands the involvement of humans throughout the entire data chain, from initial acquisition through to interpretation. As well as thinking about how people might visualize or otherwise interpret data, we also need to address how they become intimately involvement in its capture. While embedded sensors might help capture unusual perspective on a thing (e.g., internal stresses and strains) or provide insights into a thing's life away from its owners (e.g., when in transit), the deployment of sensors requires direct human intervention. By becoming owned and used, a miniature, guitar or any similar thing becomes more than just a product to be tracked through a manufacturing and distribution process. It now becomes an artefact that occupies human environments capturing everyday activities. Some of these environments and activities are private or sensitive requiring human intervention to enable, disable or even

removing sensors. A thing may also wish to gather data from sensors outside of itself in the surrounding environment which may require negotiation with or intervention from those responsible for that environment. Finally, humans may simply enjoy capturing documentation and data as part of creative and social practices. Just as people enjoy painting miniatures and playing guitars so they may enjoy filming these practices and sharing them with others through social media. This enjoyment may extend beyond direct participants in the practice to spectator, audiences and aficionados. In short, while embedded and automated sensors may certainly thicken the digital records of things, we need to recognize from the outset that capturing these records will remain a hands-on human process.

5.2 The situated and embodied use of the digital records

Our case studies reveal various ways in which digital records, once captured, can enhance the situated use of a thing. They may provide guidance as to how to use the thing, reaching far beyond traditional user guides to instead offer contextually appropriate recommendations. Thus, a guitar may recommend 'tunebooks' for a particular jam session while a miniature may provide information to support tactical planning in battle with demonstrable effectiveness metrics and analyses of previous games and strategies. In a similar vein, digital records may support learning and practice. Carolan's players suggested that a guitar might conjure up appropriate pieces to learn, capture players' attempts or even play accompany them by playing back recordings of other musical parts. Similarly for wargaming, one of the prime motivations for creating and consuming Battle Reports was for hobbyists to analyse performance. Finally, the thing may integrate recorded materials from its digital record with live use, enabling participants to replay and manipulate past recordings or play along with them. Carolan's open mic session involved summoning up recordings by previous performers in the gaps between live performances while the idea of playing along an accompaniment above fits naturally with the recent growth of interest in live 'looping' in musical performance, supported by cheaply available looping pedals.

While these ideas suggest various opportunities for drawing on the digital record to enhance the direct use of a thing, our case studies also revealed significant challenges in the areas of appropriately situated and embodied use. Proposals to augment the in-game use of wargaming miniatures proved controversial with participants as, even though they were desirable, they were seen to potentially interfere with the core of the wargaming practice. Not only might they infringe the official rules, but might also break established social norms, or simply interfere with the moment of play. Similarly, the need to continually document the construction and painting process was seen by some as interfering with the craft and pleasure of the experience.

These observations relate to two wider concepts. The first is the notion of flow that describes a particular mental state arising from the proficient performance of embodied skills such as playing a game or a musical instrument (Csikszentmihalyi, 2008; Gregory,

2008). Flow states are considered to be immersive and pleasurable and perhaps even the ideal goal state for such pastimes, so that activities that break flow, for example having to stop to record or access some data, or being pulled back into a more reflective mode by thinking about past performances, may become problematic. Second is the idea of situated discretion that (coincidentally) was articulated as a result of previous studies of traditional music sessions (Benford, Tolmie, Ahmed, Crabtree, & Rodden, 2012). The social norm of such sessions is to play music in the traditional way "by ear". While making reference to crib notes and supporting materials may be acceptable if suitably discrete, any technology that serious subverts the social etiquette may be poorly received. Attempts to use the digital record to augment the use of 'things' – especially meaningful ones that demand skilled use – will need to respect the embodied and social nature of use that are inherent in concepts such as flow and situated discretion.

5.3 Generating stories and accounts from the record

The digital records of things also have the potential to enhance their meaning and value beyond their immediate use by enabling people to generate various forms of narrative. Once again, the twin cases of wargaming miniatures and the Carolan reveal how broad these can be. At one extreme are stories concerned with the provenance of a thing in which the digital record is used to establish its identity and determine the veracity of a claimed history. This may draw on records of the creation of the thing such as the assembly and painting of miniatures and design and construction of a guitar in the luthier's workshop, but also extends to records of subsequent modifications, maintenance and also use. Guitars, for example, can acquire extremely high financial values if provably owned and played by famous musicians. At the other extreme lie more fictional 'stories' that adopt the thing as an inspiration or mechanism for storytelling. Wargamers publish blogs around the exploits of a character while composers adopt a guitar as the muse for composition.

The need to support such a diverse range of narratives, created by different people for different purposes, raises the challenges of how the digital record of a 'thing' can be shared among a community of users so that they can create personal narratives as well as how the thing itself can be mapped onto distinct stories in different situations. Augmented reality and embedded computing technologies allow a physical thing to be queried so as to deliver up digital information. Our case studies suggest that each thing may need to be mapped onto potentially many stories that can then be triggered according to the specific audience, purpose and context. For example, reading an embedded RFID sensor in a miniature may trigger different stories depending on whether it is at the gaming table (in which case we might be interested in verifiable history as part of applying the rules of the game) versus being in a display cabinet (where we might be interested in more fictional stories) while augmented-reality style scanning of the Carolan might reveal its official provenance when in a shop but link to personal compositions of its current player at a gig.

5.4 Ownership of the record

Implicit in all of the above is the notion of ownership and rights; that different 'users' as we have been calling them up to now have the ability to contribute and draw on parts of the digital record of a thing and to map the thing onto to their own personalized narratives. Our final theme therefore reflects more deeply on this notion of ownership. Our case studies reveal that the ownership of the thing itself may be complex. Both guitars and miniatures have makers who retain a degree of ownership over their design and brand, legal owners and possibly more temporary 'owners' who may be playing with them a particular moments, all of whom might be different individuals or even groups. The complexities of ownership extend beyond the physical thing itself to its digital record which may introduce further owners into the picture, for example spectators, audiences and even venues who may contribute information and data over which they retain rights.

Given these complexities, it may be more sensible to speak of notions of custodianship rather than ownership; that a thing typically has multiple custodians who adopt different relationships to it and who may contribute to and draw on its digital record. A key challenge is to establish ways for these custodians to share rights in and credit for the digital record, perhaps in our cases through creative commons (Benford et al., 2016). This sharing may prove especially tricky when we adopt a lifelong perspective on the thing as this leads us to consider transitions of custodianship. How is the digital record managed as custodians come and go? Are current custodians responsible to upkeep of the past digital record (as they are with upkeep of the physical thing)? Which aspects of a thing's past record can current custodians access? Can previous custodians retain access to their own digital records of the thing even after it has left them? Might they even somehow have acquired rights to be able to see what happens to it in the future? Such questions may be challenging enough when applied to creative objects such as wargaming miniatures and guitars, but are likely to prove extremely thorny when we consider more 'sensitive' personal objects. What rights might the various custodians of a car or a house have over its digital record during and after their custodianship? Can the new owner of my car verify that I was indeed a careful owner? Can I still access my personal memories of living in a previous house? We propose that these questions form an important agenda for further research into the lifelong digital records of everyday things.

4. Conclusions

In summary, reflecting across two ongoing projects to digitally enhance things with rich digital records that might enhance their value, meaning and use, has revealed a common research agenda for future IoT research. This comprises three key questions: how can the digital records of things be captured using a combination of manual and automated approaches? How can these records then enhance the embodied use of the thing is a suitably discrete way that respects its context of use? How can we enable people to generate a wide variety of stories and accounts of the thing from its record? And finally, how can we revisit current notions of ownership to reflect a more fluid sense of custodianship,

both of the digital record as well as of the thing itself. Further work in both settings is set to continue, with the ultimate aim of potentially generalising the findings into wider and different contexts and domains.

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