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Ecology of archaeological information work

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Abstract

Bringing together insights from the earlier chapters of this book and empirical work on archaeological information work in the context of the ARKDIS research project, this chapter sets to propose a more systematic understanding of the contemporary archaeological information work. Building on systems thinking, Gibsonian ecological approach and the work of Pickering and Stengers, the chapter proposes a model of archaeological information process based on the metaphor of making and taking information rather than that of a flow of information from producers to its users.

Introduction

After a series excursions to the changing information work and knowledge making in archaeology, this chapter sets to propose a more systematic understanding of the contemporary archaeological information work. Such an understanding is useful both for unravelling why archaeological information work is as difficult as it seems to be according to the snapshots of specific archaeological practices offered by the earlier chapters in the volume and the common knowledge of archaeologists alike. Simultaneously, it is helpful in developing information management practices both in archaeology and beyond. Informed by soft systems thinking, Gibson's ecological approach, infrastructure studies and information management literature, its focus is on, rather than in archaeology, even if, as the reckoned theoretical premises imply, the subject of inquiry unavoidable lingers between archaeology and the study of archaeology. Taking the latter perspective, a closer scrutiny of archaeological practices ties it also to the broader landscape of information work everyday life contexts beyond specific contexts and situations of archaeological work.

Archaeology as a soft system

Looking back the earlier chapters of this book, archaeology and archaeological information work can be described without much controversy, using the term coined by Nelson (Dechow & Struppa, 2015), as deeply "intertwingled" enterprises. At the same time, archaeology is not a haphazard enterprise. There is a great deal of systematicity both in the ideals that guide archaeological practices and information work from theory and methods to policies and guidelines, and in how archaeology is conducted in practice. As such it is apparent that the

systematic understanding of the archaeological enterprise requires an inherently complex frame of reference even if the aim would be to say something simple about them. It is this paradox of the coexistence of apparent intertwingularity and systematicity that has guided the direction of inquiry in this chapter and its orientation towards soft systems thinking. This perspective gives some basic keys to unlocking some of the intricacies of how archaeological knowledge comes to being in the contemporary society. On a very basic level, the examples discussed in the volume from widely different areas of archaeology evince of the systemic rather than purely random intertwingularity of how archaeological information comes to being, what the information is and what outcomes and implications it has. Stenborg's discussion of what is real, what is reconstructed and what implications the perceived reality of artefacts and unreality of digital objects have highlight the intricate relation of material forms of information and how it is experienced.

As originally drafted by Checkland (1981), the soft systems approach was proposed as a method for explicating and understanding constellations of activities, technologies and people that are difficult to quantify in formal terms of technical systems. In the context of archaeology these constellations range from the fieldwork and scholarship to governance of archaeological activities in the society and beyond to public archaeology and education. The soft systems approach builds on the perspective of systems thinking to conceptualise activities and their constituents in systemic terms, however, at the same time, explicitly refusing the reductionism of natural sciences and the expectation of the general systems theory to function as a general theory of everything in social sciences (Langlois, 1983, 581). In comparison to the general systems thinking, the novelty of soft systems approach is to acknowledge the significance of the human factor (Checkland & Holwell, 1998, 46-47). The second major difference is that while hard systems approaches tend to conceptualise the world as systemic, the soft approach sees the process of inquiry as systemic (Checkland, 2000). In this sense, it represents a similar shift than the move from first-order to second-order cybernetics, from observing external systems to foregrounding and problematising the role of participant and observer in the study of systems (Mingers, 2014). While acknowledging the complexity of systems involving both technical and non-technical components, soft systems approach adheres to the functional rationale of engineering in how its attempts to provide a structured understanding of the functioning of those systems and especially in the context of the Soft Systems Methodology (SSM), to function as an instrument of change in the spirit of action research (Checkland, 2000). Even if it is common (e.g. Schatzki, 2001) to contrast systems theory with practice and activity centric approaches (including ANT and especially practice theory), in its strive to use a systemic inquiry to organise complexity, the soft systems perspective can be seen as complementary rather than as their antithesis. An example of an approach that puts equal emphasis on human and non-human actors is Pickering's socio-material approach, which conceptualises the intermingling of material things and human-beings as a mangle of practice. Pickering acknowledges that objects make things to happen but puts specific effort to explicating the differences between the agencies of material and social actors (Pickering, 1995).

The central tenet of this chapter is that, similarly to other types of constellations of interrelated activities, also archaeological practices can be conceptualised as forming a soft system, or multiple overlapping and parallel inter-linked soft systems within, on the boundaries and outside of 'archaeology'. The benefit of this approach is that it provides us keys to explicate existing interrelations and on-going reconfigurations of people, technologies and practices in how archaeological information work and knowledge making changes. The emphasis of soft systems thinking to problematise the role of observer/participant (Mingers, 2014; Checkland, 2000) has

been central to the inquiry that lead to the writing of this volume in a group consisting of archaeologists and non-archaeologists but also from a conceptual perspective, as a starting point of interrogating how different actors can be observers and/or participants in the archaeological enterprise. On a conceptual level, I am inclined to propose that system can be understood, borrowing from Hiebert (1983), as a "centred set" within which everything has a certain distance to archaeology, rather than seeing it as a categorically bounded set of things either being archaeological or not. These 'archaeological' systems stretch from the practices of fieldwork and archaeological scholarship to the systems of governance of archaeological activities in the society, of development of technologies, methods and approaches used in archaeology, archaeological pedagogy and aesthetics. They incorporate archaeological and archaeology-related activities from artefact analysis and surveying, technologies of documenting and managing archaeological information to human actors, including archaeologists, administrators, land developers, curators and museum visitors. As such the system of systems of which archaeology is a part, is far larger than the discipline of archaeology and as Olsen (2012) remarks, the ecology of archaeological practices does indeed go well beyond what archaeologists do or did. Even if might be tempting to see archaeology as a closed domain with little inference with the society at large, the archaeology-as-a-system is an indivisible part of the society-as-system. From this perspective, as long as there is a society, there is no archaeology beyond the society and as long archaeology is carried out in the society, the society is not archaeology.

There are obviously many different alternatives to theorise work and information activities in general and within a particular domain. Proponents of relational theorising have criticised systems theory of substantialism (Schultze, 2017), a criticism that applies also to soft systems thinking. The real substantialism of the approach depends, however, somewhat on how much focus is put on the system-as-an-artefact and how much on the processes of their becoming, practicing and change. Some of the advantages with the soft systems thinking is that it accounts for both human and non-human actors and acting, it acknowledges the heterogeneity of their interlinkage and the heterogeneity and number of different factors that influence and transpire in these relationships and their becoming. It is also reasonably holistic and while being helpful in analysing and understanding information work, it is prescriptive and action-oriented process that explicitly aims at empowering human-actors to improve a situation.

The diverse aspects of archaeological work discussed earlier in this volume illustrate the breadth of archaeological activities and actors with a stake in archaeological work. Even if, as Löwenborg reminds, the most of the archaeological work never makes it to the headlines in mainstream media, archaeology makes a difference in a broad variety of contexts. Development-led archaeology is a legal requirement in Sweden and in the large part of the developed countries and an elementary part of the process when railways, roads and houses are built and renovated. Archaeological sites and museums are popular sights as Petersson notes. Archaeological considerations play a significant role in the contemporary cultural and cultural heritage policies as both Börjesson's and Huvila's, and Stenborg's chapters evince.

Instead of digging deeper in the specifics of different archaeological practices using the formal tools provided by Checkland's Soft Systems Methodology, we refer to the notion of soft systems in more general terms as a framework that helps us to understand the interconnections, gaps, synchronicities and asynchronicities of archaeological and archaeology-related practices from fieldwork and documentation to communication, archiving, administration and repatriation. Each of these activities make a soft system of its own, some of the activities come together in larger systems and the entire archaeological enterprise as a whole, forms a vast soft system of systems.

All of the systems comprise of both human and non-human actors that form a mangle-like (Pickering, 1995) systemic apparatus of archaeological activities. The different chapters of this volume have described and discussed a large number of these actors, both humans and non-humans but also actors and constellations of actors that increasingly overlap. Policy-makers and policies are both actors with an influence on how archaeology is exercised in the society and how the conditions for its longevity are articulated and practiced now and in the future. Museum visitors, curators and exhibition designers all participate in communicating archaeology together with a broadening range of digital and non-digital technologies that mediate the visitor experience. Local communities, both close and far, are actors with a stake in what and how archaeology is perceived and exercised in the society, and how and when archaeological artefacts participate in the making of both archaeology, and identities and practices beyond that what is traditionally understood as archaeology. For archaeologists, their trade is increasingly intertwined with the co-acting of new technologies and methods and technology and methods experts from statistics and mathematics to computer and natural sciences.

Another reason of referring to soft systems thinking is that it gives a possibility to look closer into how digital technologies reconfigure archaeological practices and how these reconfigurations in different parts of the archaeological enterprise influence each other. Löwenborg points to new opportunities large data sets provide for archaeological research. The novelty is not only in that a new tool has been introduced to perform an old task of conducting large scale analyses but that the technology makes it possible to ask new questions. The same applies to photogrammetry based field documentation in dell'Unto's article. Field archaeologists do still excavate but the process of digging and interpreting the findings is changing. In comparison to the traditional pen and paper documentation, photo-documentation intertwines documentation and excavation more intimately than it was possible before.

It is not enough to describe how a technology enters a mangle of practice (Pickering , 1995). It is necessary to take the challenge of Stengers (1997) and take a risk to try to show how certain technologies have very specific implications on the particular parts of the archaeological soft system and the outcomes these systems produce. These technologies do not enter the soft system out of nowhere. They are introduced by humans and humans use them to achieve particular goals. The technology itself can be anything from hard technologies like digital photography and laser scanning to soft social technologies and their hybrids from digital archives, digital government to digital humanities (specifically conceptualised as technologies). The 'digital' incorporates a reference to technical form of digitality as a binary representation, but stemming from the digital understood rather as a social than a technical term, digital is a property of things understood as being related to 'digital' rather a definite token of its belonging to the technological digital realm. Especially in the museum contexts, the intrinsic value of inserting digital 'elements' in exhibitions is a convincing example of the essential rather than instrumental significance of digital technologies. However, even if similar tendencies would more vested in other contexts, they are not necessarily absent. Digital technologies have a capability to change archaeology and archaeological work in field as Dell'Unto demonstrates in his chapter, they can helpful in providing new perspectives to earlier collected data and to bring together insights from small, individually meaningless, field projects. Further, as Stenborg's examples show, even if digital technologies might not function as a substitute for physical restitution of artefacts, or as Boast and Enote (2013) critically remark that virtual repatriation is virtual but has little to do with repatriation, it can still provide means to make archaeological collections more accessible for different audiences in both physical (as in Lödöse) and non-physical (Brazilian collections in Gothenburg) forms.

Archaeological work and information work

Instead of attempting to say something definite about the digitisation of archaeological as a whole, the main interest in the exploration of archaeological work in this book, has lied in archaeological information and its role in how archaeology is performed. While doing this, it is impossible to avoid saying something more general and by discussing the digital in the context of archaeological work, much of that discussion is unavoidably about information. Star and Strauss (1999) made a widely-cited distinction between visible and invisible work that is helpful in understanding the relation of work and information work. A simple definition of work is to see it as an activity with purpose, meaning and value (e.g. Huvila, 2009). In systemic terms, work can be considered to form a theoretical system consisting of multiple secondary, mutually overlapping systems. The premises, objectives and perceived implications of work differ between individuals. Often, the understanding of what counts as 'work' is normally shared in a community but the understanding of any particular instance of work as 'work' does not need to be completely the same (Star & Strauss, 1999).

In spite of the apparent overlap of work and information work, it makes sense to make an analytical distinction between the two. In the literature, the notion of information work has been used to refer to the informational sub-work that is a part of all types of work (Huvila, 2009). All work, including diverse configurations of archaeological work incorporate elements of seeking, organising and using information whether it is codified, formal or informal, found as a result of an intentional effort or discovered serendipitously. As a work-related second-order activity, it is comparable to computing work of Gasser (1986). Even if information work can be explicit and in some cases even the principal activity of a professional information specialist or archivist, also in the context of archaeology (e.g. Huvila, 2016), in most cases it is infrastructural and "invisible work" (Star & Strauss, 1999) that silently supports and makes the primary work possible. Curatorial work at museums and especially the work of keeping and sorting out correct kind of data for archiving discussed by Börjesson and Huvila beyond the, in practice, rather symbolic guardianship come close to typical examples of invisible information work discussed in the literature. They are necessary and infrastructural by their nature but remain largely unrecognised as a crucial part of the archaeological enterprise. Even those who are involved in primary information work are performing secondary, invisible information work to support their main work. Löwenborg's and Dell'Unto's chapters show how this invisible work is omnipresent in archaeological research and fieldwork. In many cases its invisibility stems from its conspicuity as an integral part of the archaeological enterprise. However, as both Dell'Unto's work for the development of field documentation methods and Löwenborg's work on legacy data show, its invisibility becomes evident first when work practices change and its stakeholder begin to question the compatibility of established procedures of work in the new situation.

The exploration of the convergence, frictions and change of archaeological information work so far in this volume shows its irrefutable diversity. Archaeological knowledge is not made only at the (literal) trowel's edge (cf. Berggren & Hodder, 2003) in field or at the universities. Digital technologies from 3D documentation to GIS have become or are becoming a new trowel, a tool for archaeologists to (almost literally) unearth new knowledge. Petersson's studies on how archaeological information is used and unused at museums reveal another perspective to how archaeological knowledge is made in another milieu from highly different premises and framed within another field of a practices. In a strict sense, it is not implausible to doubt that archaeology would form one single domain. To a certain extent, everything that is called archaeology or related to 'archaeology', in Hiebertian (Hiebert, 1983) terms belonging to the particular centred

set, can be dubbed as archaeological information work but it does not mean that all of these activities would be equally influential or central in the general process of making archaeological knowledge – understood as the knowledge that is generally and in specific cases appreciated as central knowledge within the domain of archaeology. They are certainly influential for their own right within their own contexts but they do not necessarily play a central role in archaeological thinking (Orser, 2014), in how archaeologists use logic and analogy, compare, contextualise and evaluate materials. Therefore, it is significant to note, from the soft systems perspective, the diverse worldviews that lead to different forms of archaeological knowledge and their associated forms of information work by their own right without losing the sight of how they are entangled together in producing a mesh of knowledge. Even if they are connected, archaeological fieldwork, landscape analysis and public archaeology all differ in their premises and are simultaneously distinct branches of work with their respective informational second-order activities i.e. information work. At the same time, however, they can still be centrifugal to and belong to the centred set (Hiebert, 1983) of archaeology, some of them being more distant from its nexus than others. In many respects, the information work of professional and amateur archaeologists can be close to each other (Stebbins, 1992), and their distance to the kernel of archaeology can be very similar. On the other hand, as Stenborg shows in his discussion of artefacts in public contexts, the particular actions and circumstances when and where public archaeology takes place, can put them on highly different trajectories and positions in the centred set (Hiebert, 1983) with their distinct local discourses (Deeley et al., 2014).

On the basis of the observations on the diversity of the archaeological enterprise, it is easy to agree with Morville's (2014) claim that the human nature and especially our impatience, and mechanistic tendencies in organisational cultures are, or at least can be, problems also in the context of archaeological information work. More patience with archaeological and archaeology-related work could be helpful in trying to understand, communicate and take into consideration the diversity and change of archaeological information and its implications and meaning for different stakeholders. Simultaneously, balancing between the need to standardise and improve the interoperability of archaeological information (underlined for instance by Löwenborg and Börjesson and Huvila) and the inescapable diversity of perspectives, vividly exemplified by Stenborg, requires an organisational attitude that takes seriously the complexity of archaeological enterprise and resists temptation to formalise it in excessively mechanistic terms.

Infrastructures of archaeological information work

A closely related notion to information work is the information infrastructure. They are both constituents of the soft system of archaeological work but also systems in their own right with particular roles in the larger constellation how archaeology is achieved. There has been a raising interest in the concept and related notion of knowledge infrastructure in various branches of information sciences, science and technology studies and anthropology (Karasti et al., 2016), and in the relatively new, proposed cross-disciplinary field of infrastructure studies (Edwards et al., 2009; Ribes et al., 2012) and its branch of information infrastructure studies (Bowker et al., 2010). Information infrastructures like all infrastructures allow, facilitate and shape our surroundings and their conditions, and form an invisible substrate for the activities. Rather than being an essential thing an infrastructure is in a constant state of becoming (as for Whitehead, 1978) and as Star and Ruhleder (1996) remark following Engeström (1990), it is more appropriate to ask when is an infrastructure rather than what it is. They continue to note that infrastructures tend to be invisible and become discernible only when they fail. We are "plugged

in" (Star & Ruhleder, 1996) in them as a part of our daily activities, and according to their now famous breakdown, they are characterised by embeddedness, transparency, their reach or scope beyond a single event of practice, they are learned as a part of membership, they link with conventions of practice, they are embodiments of standards, built upon an installed base, and as noted, they become visible upon breakdown (Star & Ruhleder, 1996). Star and Ruhleder (1996) note further that information infrastructures are not to be considered as substrates that carry information but rather in Latourian (Latour, 1993) sense dichotomies of mind and body that traverse the great divide of human and non-human, or perhaps in Whiteheadian (as for Whitehead, 1978) sense, refute the existence of these divides altogether. Star (1999) posits that an information infrastructure can be read either a material artefact constructed by people, a trace or record of activities, or a veridical representation of the world. Mongili and Pellegrino (2014) note specifically on information infrastructures that they go beyond information artifacts in that they are relational to organised practices Star & Ruhleder (1996). Some information artefacts become infrastructures (Star & Lampland, 2009) like some artefacts become information (Buckland, 1991) depending on situation. In an attempt to present a working definition of information infrastructures, Monteiro et al. state that "[i]nformation infrastructures are characterized by openness to number and types of users (no fixed notion of 'user'), interconnections of numerous modules/systems (i.e. multiplicity of purposes, agendas, strategies), dynamically evolving portfolios of (an ecosystem of) systems and shaped by an installed base of existing systems and practices (thus restricting the scope of design, as traditionally conceived). Information infrastructures are also typically stretched across space and time: they are shaped and used across many different locales and endure over long periods (decades rather than years)." (Monteiro et al., 2012, p. 576), but as Borgman and colleagues (2016) stress, they do not persist if they are not taken care of. The fragility of infrastructures has been very obvious throughout this volume. Löwenborg shows that their fragility becomes evident already before an infrastructure comes into being. Stenborg and Petersson both touch upon the issue of how use and reuse makes and unmakes infrastructures in museums and museum collections. Dell'Unto, and Börjesson and Huvila do for their part suggest of the fragility of information infrastructures when the forms and formats of documentation are changing.

Unsurprisingly, a multitude of infrastructures can be traced in the backyard of archaeological information work. Olsen (2012) points to the significance of the emerging heritage legislation as a central infrastructure of archaeological practices in the nineteenth and especially in the twentieth century. He also refers to standards and knowledge infrastructures as infrastructures for archaeological knowing, thinking and remembering. The institutionalisation of archaeological work, its administration and management at universities and societies, national and regional, public and private organisations, collections, laboratories and scholarly journals has simultaneously been a process of establishing infrastructures to support, not only archaeology at large but also more specifically, archaeological information work. Huggett (2016) draws further attention to the invisibility of infrastructures, and unawareness of the consequences of investing and building "cyber-infrastructures" for archaeological work. He draws on infrastructure literature (e.g. Kitchin, 2014; Day, 2014) and Svensson's (2015) call for a more critical awareness of infrastructures and their implications in humanities research in general. The critique is more than timely at the time when new digital forms and formats of information from three-dimensional field documentation to digital objects and re-materialised artefacts and their preservation and archiving are central concerns of the field but when much of the work is still been done on the level of building the technical rather than socio-technical infrastructures. The essence of Svensson's (2015) and Huggett's (2016) concern is that on a profound level, in addition to supporting, facilitating, enabling and hindering information work, information

infrastructures also shape what is recognised as information or knowledge (Bowker, 2005). In case of the large-scale (re)use of GIS data from earlier excavations, in spite of the brave efforts of individual researchers, the information is limited by that what is achievable to compile from earlier data sources. Similarly, when discussing the longevity of archaeological archives, the archived information is dependent on the infrastructure of heritage administration that both explicitly and implicitly determine not only the conditions of how and what becomes information but also indirectly, the information itself. The same applies to all infrastructures in the precious chapters from museums to digital documentation technology. Platforms and infrastructures, both in their respective ways (Plantin et al., 2016), shape both the information itself, the premises of how it can be acted upon by acting indexically (Day, 2014) and what consequences the information has (Huvila, 2009). As Day (2014) notes, the work upon and beget vocabularies to express ideas, they function as cultural forms and social norms of what is 'useful' and they stabilise meaning in time. They not only act as indexes but are indexes and providers of social, cultural and physical affordances and constraints. The shared commitment to infrastructures in archaeology (Olsen, 2012) and in other disciplines (Bowker, 2005) are generative of not only objects and forms but as Olsen (2012) points, on the level of ontology. Naming things not only changes their label but changes how they are perceived and acted upon, and eventually, what they are for us.

Ecology of information work

Even if there would be no reason to question the potential of profound ontological impact of digital technologies, the empirical cases discussed in this volume – even if they provide us undoubtedly only a very selective outlook of what is happening in archaeological work – have conspicuously enough, underlined how the conduct of archaeology has changed, not that archaeology itself would have become something radically different. It might be relevant to ask whether the principal change has been, at least so far, an ontological or an epistemological one. The first impact of using digital visualisation at museums, three-dimensional documentation in field, and combining data from small scale surveys to large datasets is in how knowledge is being made rather than what the knowledge itself is. Both Dell'Unto and Löwenborg insinuate of new questions that can be asked by exploring three dimensional models or by applying machine learning on archaeological big data but rather than emerging out of the digital technology, it might be relevant to ask whether they would rather be an outcome of an evolving epistemological process.

The apparent resistance of archaeological work to bend to formalisations raises, however, a question of whether it is relevant to talk about archaeological processes or information processes after all. From the work of Gardin (1980; 1999; 2003) to formally describe archaeological reasoning to more mundane efforts of describing various archaeological work processes in different countries (e.g. De Roo et al., 2016; Riksantikvarieämbetet, 2016; RAÄ, 2015) there has been many attempts to formally describe intellectual and practical processes in archaeology. The diversity of archaeological practices and the difficulty of these efforts to capture the details of the enterprise might sound like a reasonable justification for claiming that no such process exists. The examples discussed in the volume sanction the claim even if, as the texts of for instance Dell'Unto and Löwenborg show that there are local information processes that, even if there is variation, are fixed to a degree. Processes and workflows are even more clearly visible in the archiving of archaeology in the text of Börjesson and Huvila. In this respect, it seems somehow plausible to claim that archaeological information process does not indeed exist but there are

multiple both mature and rudimentary archaeological information processes, and even more importantly, archaeological work is guided by an idea of processes. Even if the actual workflows would be shifting, the idea of working according to a protocol and following a process is in the heart of how archaeology is being performed and how archaeological knowledge is made. This becomes apparent in how archaeological work is documented in field, how the documentation is archived and how the documentation needs to retain a reasonable degree of uniformity in order to be useful in local and global contexts. The idea of a process does not, however, necessarily correspond fully with the actual pace of action. The diversity of reporting and documentation and difficulties of bringing together larger sets of data suggest that the soft system of archaeological information work is closer to a mixture individual and collective "information journeys" (Blandford & Attfield, 2010) than following a formal protocol. As Greyson (2016) suggest of the evolution of information practices in time, the evolution of archaeological information work can also be described as a function of time, participants, settings and events. In comparison to contemporary processes, in archaeology, the time is long and the continuum of the constituents of information work span from the events of the remote past to the future. Archaeology is beyond any doubt an example par excellence of situated action (Suchman, 1987) within which the situations are simultaneously local, global, contemporary and distant in time.

While the soft systems approach helps to understand the mangle of archaeological practices in systemic terms and gives a promise of being able to organise our explorations of them in a system that is capable of providing insights into the theory and practice of archaeological information work, the approach does only partially address the change of the systems. As systems theory in general, it is premised by substantialist rather than relational assumptions. According to general systems thinking, systems have a tendency to resist entropy and turn back to stability. They change in accordance to their internal dynamics and external influence and proceed to new states of stability. The internal and external dynamics of technological and social systems have been compared to evolutionary systems and the notion of ecology has been used both in literal and in a metaphorical sense to describe change in these contexts. The ambition of ecological metaphors has been to shift emphasis from the mechanistic views of social systems to a softer perspective largely in parallel to the introduction of soft systems thinking as a critique of the earlier tenets of systems theory. At the same time, the notion of ecology is helpful in shifting the focus from conceptualising systems as essential entities towards understanding them from the perspective of process philosophy as patterns in the process of incessant becoming.

The concept of the ecology of information work (Huvila, 2006, 2009, 2011) is based on the ecological approach of Gibson (1979) as an ecological model to describe the dynamics of the co-evolution of information work and its infrastructures (Huvila, 2009, 2011). The central assumption of the model is that information infrastructures (the invisible substrate of information work) that function as a substrate for specific knowledge organisation systems (like information systems, models of classification) constrain or privilege particular ways of using information as a part of their daily pursuits i.e. engage with information work, a sub- or meta-work related to all types of ordinary activities from professional leadership and teaching to carpentry, sports and collecting stamps. Correspondingly, specific configurations of information work warrant for particular types of information infrastructures. Some of the characteristics of information work i.e. warrants (Howarth & Hourihan Jansen, 2014) can point to same types of infrastructures but sometimes they can propound for diagonally different approaches. Whether a particular infrastructure can cater for the different warranting factors, depends on its capability of incorporating new entities and relationships, or hospitality (Beghtol, 2002), as this capacity is referred to in the knowledge organisation research.

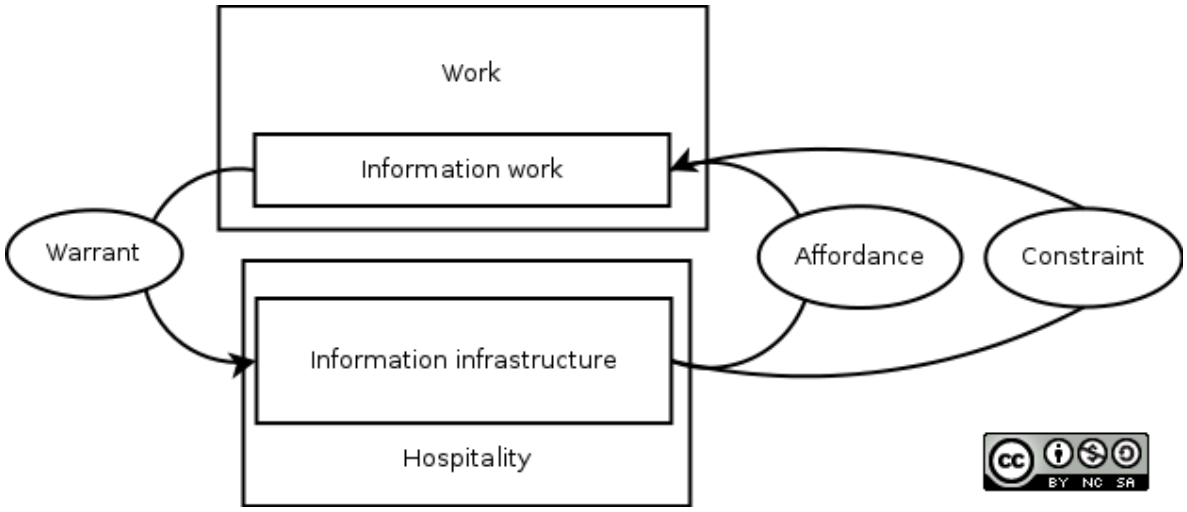

Figure 1: Ecology and warrants of information work and its infrastructures. Developed on the basis of an earlier model published in Huvila, 2009.

An adapted, somewhat simplified version of the ecological model is presented in Figure 1. Applied in the context of archaeological information work, the model suggests that specific models of documenting and communicating information lay foundations to how information is used in archaeological work. Dell'Unto shows in this volume how new approaches to documenting in the field can pave way for new approaches to analyse and interpret the archaeological stratum. Similarly, according to the model, using the Gibsonian terms of affordances and constraints (Gibson, 1979), the infrastructures resist (i.e. constrain) the making of particular types of informational infrastructures and provide for (i.e. afford) the emergence of others (Huvila, 2009). In this volume, Löwenborg has illustrated how the contemporary information infrastructures resist the ambitions to perform large-scale analyses and work towards archaeological big data, and what happens when in the case of machine learning approach, a solution from outside collides with the data that is available.

The approach can also be paralleled with the notion of ecology of practices of Stengers (2005). Olsen (2012) has earlier built on this particular notion while conceptualising archaeology as a discipline marked by its "particular kind of care, obligation, and loyalty to things" Olsen (2012, 1). In contrast to Olsen who delves in the theoretical foundations of archaeological work and its pursuit of mediating past and present, the focus of this volume has been more modest with its focus on archaeological information and information work. From a methodological perspective, Stengers makes an important claim of the need to define no practice like any other that is useful also for the ecology of information work. Even if a specific practice, or work would have similarities with other types of work (or practices), it does not mean that in an inquiry of particular work that work could or should be equated with another. Information work should be approached where it diverges from other types of information work without "insulting" (Stengers, 2005, p. 184) information workers and their perspectives.

In the context of our exploration to the realm of archaeological practices in the digital society, the model provides a framework to explicate the co-evolution of archaeological practices and digital technologies as their current and emerging (proto-)infrastructures. Similarly to how Stengers

(2005) and for instance, Hardin (2009) and Huvila (2012) building on the latter, have underlined the need to appreciate the fact that individuals have their rationale for doing what they do even if it would be momentary and fleeting, we suggest that there are valid reasons why archaeological information work is conducted as it is done, and why it might and might not be necessarily very well aligned with the existing infrastructures. We are not suggesting that all (digital) technologies would make an infrastructure but we posit that they have an infrastructural potential, a capability to become infrastructures or a part of them. As they become an invisible substrate of archaeological work, similar to how the road network, electricity, plumbing or the Internet are to the daily lives of the most of the inhabitants of the developed world, a technology (whether it is digital archive, laser scanning or geographical information system) becomes or is absorbed into an infrastructure.

Making and taking information

Even if this book started with a reference to a task of providing a better understanding of archaeological information process, one of the most significant insights we can make by reading and reflecting upon the text so far is that there might not be a process after all. Or, that there are processes but they do not link together to form a general process of how archaeological information flows from the field to the archives, desks of researchers, books, articles and museum exhibitions on another than, at the most, a highly abstract level. Or that it is possible to outline a process as, for instance, De Roo et al. (De Roo et al., 2016) and the Swedish DAP project (Larsson et al., 2017) have done but that the process is an abstraction that possibly hides as mich as it reveals. The paradox is that an archaeological process can be convincingly and for good reasons defined as a crafted continuum of material worlds that spans from ruins and remains to their proxies (Shanks & McGuire, 1996), as an information flow (e.g. De Roo et al., 2016), or as labour used to turn archaeological imagination to texts, plans and documents (Witmore, 2004) – and digital data. As a whole, the intricacies of modelling archaeological information process and determining how to appraise the model and its object reminds of the perplexities of models and modelling. Stengers (1997, 95-96) argues that models can be essential to understanding phenomena but they have a tendency to become that, namely essential. Similarly to publications, also models and modelling are techniques of simplification (cf. Star, 1983) par excellence that conceal complexity of work. In this respect, as contradictory it may sound, a model of information work should be seen as much as a reminder to be critical of models of information work than a model itself.

Information is produced not only by professional field archaeologists and scholars but also by archivists, documentation and analysis technologies and the general public. Similarly, it is not flowing from one individual or group to another even if it is not inappropriate to argue that there is a process and continuum. The mangle-like ecology of archaeological practices, it might be more appropriate to talk about an ecology of knowledge production, information seeking and situational appropriation of available information (Huvila, 2015), an ever-changing soft system with temporary and similarly changing smaller and shorter local formal processes or systems of producing and supplying information for specific purposes and tasks. The introduction of digital tools in the different parts of the system has changed the connections between established information processes, expectations of how information should be searchable and usable. Knowledge production, different actors are creating information that is being appropriated by others. Information seeking is characterised by a combination of purposive searching and encountering and production for anticipated, in practice, imagined community of users, which partly is and partly is not anchored in the real needs and wants of actual users both at the present

and in the future. Instead of imagining the process as a flow of information, it is posited that a better representation of the ecology of archaeological information process could be a continuum of knowledge and information making and appropriation. A central advantage of this approach is that it explains why information flow fails without resorting to an explanation that frequent failures are an anomaly. They are a feature of the soft system and a reason why standardised catalogues are an attractive approach for solving information management problems but tend to be a poor solution, especially from the perspective of users coming from different contexts and with different questions in their minds than those who created the standard and the catalogue. The approach accounts also why narrative (e.g. Boast & Biehl, 2011) and linear storylines (e.g. Vatanen, 2004) appear as a useful in enhancing the flow of information, and why it is fully possible that archaeological work is both about revisiting knowledge (or documentation) about the past (Hicks, 2016) and "past at the present" (Edgeworth, 2006, xi), a pursuit of acquiring knowledge from inside (Ingold, 2016) at the trowel's edge (Berggren & Hodder, 2003).

The Figure 2 presents a sketch of the idea of how one actor makes information and how another takes it in use. These links of making and taking form a practically infinite embroiled network of such connections between different actors. Taking is better seen as a form of appropriation than direct utilisation. It allows actors to use information in different situations in hand and make it useful from their premises now and here. Individuals and collective actors use technologies to produce, change and access information, the situations take place in the different types of material, spatial and temporal premises, and are supported by informational and non-informational infrastructures that, for their part, are influencing and influenced by the actions of the involved actors.

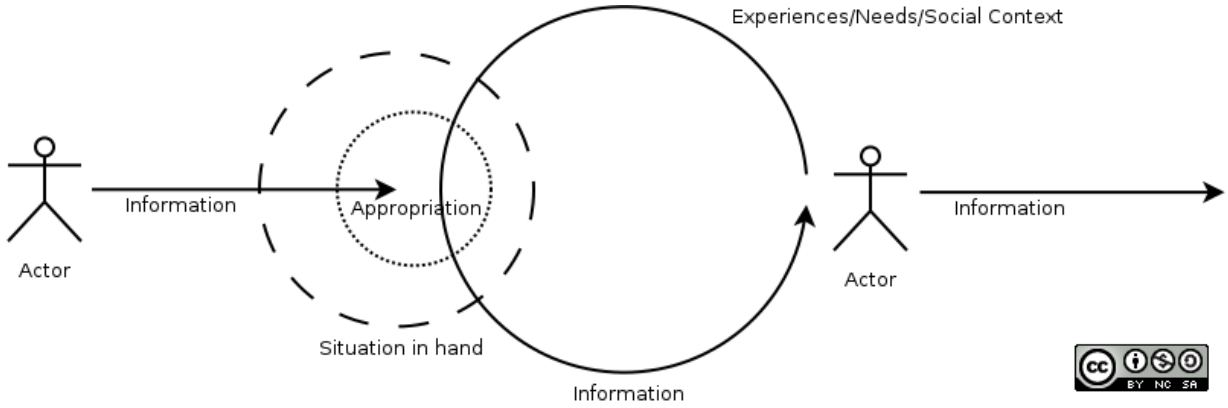

Figure 2: Making and taking information.

Examples of this specific pattern of the relative disconnected making and taking of information can be seen in diverse contexts throughout the previous chapters of this volume. The most apparent it is when information is produced by one actor and taken into use by another one in the context of development-led archaeology and the use of archaeological archives. A field archaeologist produces a set of documentation with a certain idea of its possible use in the future but both its longevity and usefulness for diverse purposes from administration to large-scale predictive analyses of settlement patterns is not directly embedded in the documentation itself but rather made at the moment when it is appropriated for use. Similar patterns prevail when archaeology is communicated to the general public. As Petersson with Larsson convincingly shows, a museum makes archaeological information its own as a part of the process of producing

an exhibition. The story told is not in the field documentation but it is made out of it and combined to information, which is similarly appropriated from other sources. The same pattern is discernible in Stenborg's chapter in how artefacts from a specific location are turned to a very different kind of information when they are placed in museum collections distant to the original context where they were found, and how these collections and their individual constituents are appropriated to inform actors close to their new home institutions and those coming from the area where they were discovered. Artefacts are engaged in an iterative process of making artefacts informative by originally creating them for their original intended use, disposing them, and unearthing, documenting and depositing them in museum collections. Simultaneously, they are engaged in a counter process of taking them into use both before their eventual disposal, and after their (re)discovery and inclusion in archaeological collections. There is no doubt that similarly to how contemporary actors have widely diverging views of what these artefacts are and how they are useful, usable and informative, also their past and future have had and will have a comparable variety of perspectives to the same question.

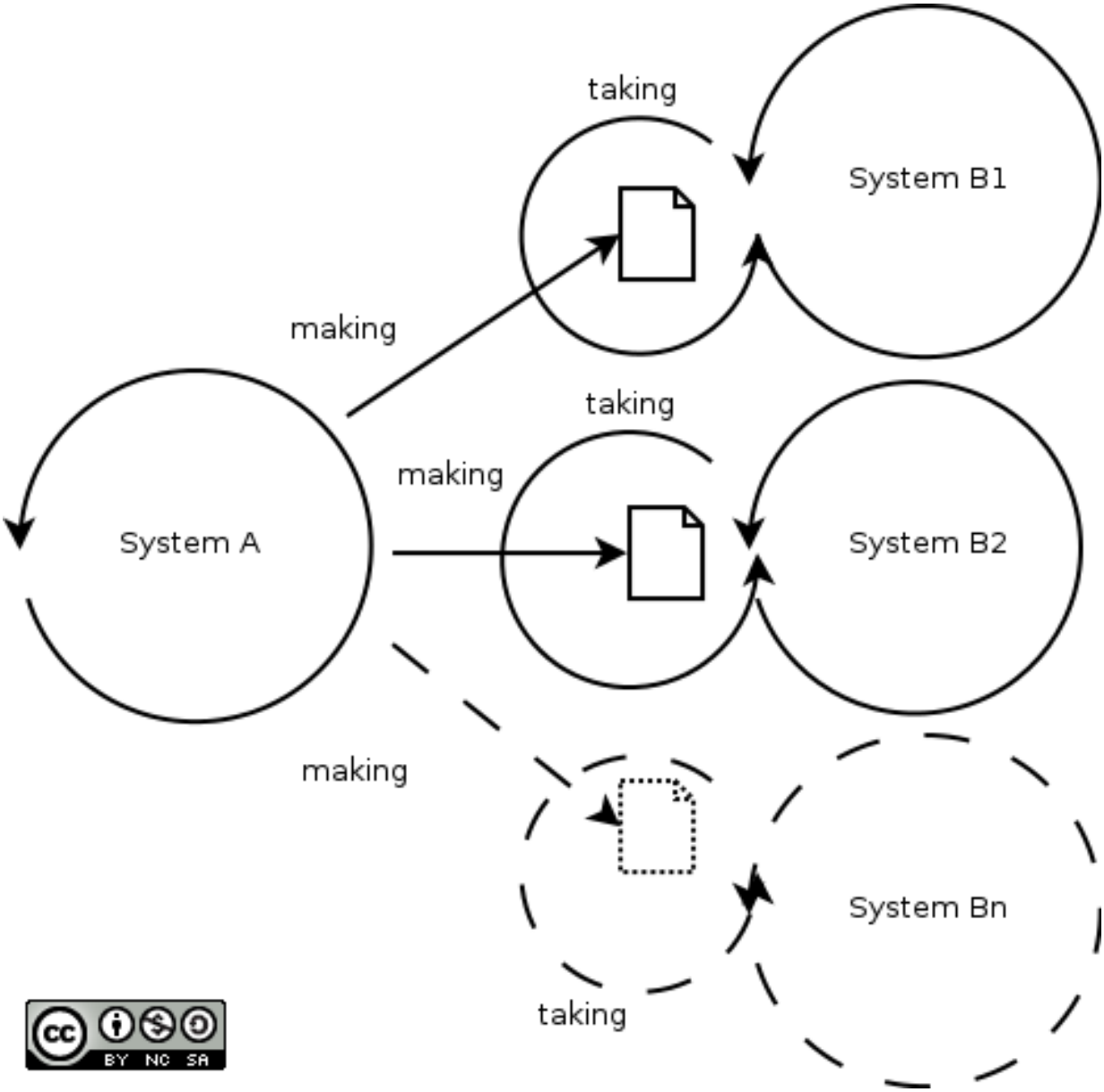

Figure 3: Making and taking on the level of interlinked (soft) systems.

Even if the exchanges, the making and taking are easiest to discern on the level of individual actors, in a broader scope they are systemic like the archaeological information process as a whole. It is not merely individuals who make and take but (soft) systems that produce 'output' which is appropriated or taken by other systems illustrated in the figure 3. From this perspective, archaeological units, working groups, contractors, museums, community groups near and far, archivists, research teams and lines of inquiry to mention a few, are systems that make and take information. The information made by a single system can be ending up as taken by plethora of different other systems, which for their part, make new information out of that they have taken leading to an increasing proliferation of both information and what is known on the basis of an 'original' observation.

Living with making and taking

It would be tempting to conclude this chapter by stating that archaeology is a complex constellation of practices. I do feel, however, that complexity is a bad conclusion especially if the term is used to refer to a non-specific randomness rather than a specific form of meaningful, "interesting" complexity (cf. Bawden & Robinson, 2015). At the same time, it would be equally tempting to repeat earlier observations on the nature archaeological information work and to reconstitute the validity of the problems of organising archaeological information (e.g. Lavell, 1981; Oikarinen & Kortelainen, 2013). There is no doubt of the validity of this observation but it does little to help us to understand the intricacies of archaeological information work, and when turning to the next chapter of this book, to explicate how archaeology changes in the digital society.

The current chapter has described archaeology as an intertwingled ecology of practices rather than a linear or quasi-linear process. However, rather than portraying this ecology as an utterly rhizomatic and convoluted, there is a great deal of systematicity and patterns both on the level of ideals that ushers the imagination of archaeologists and other stakeholders of archaeological work but also in the practices themselves. Further, as the brief excursions to diverse instances of archaeological practices and information work have shown, doing archaeology is situated and premised by a complex set of infrastructures each with its particular affordances and constraints that permit and impede specific approaches to how archaeology is carried out. Doing archaeology and working with archaeological information are not as much a flow as it is about how information is made and taken in diverse situations and contexts and how infrastructures of archaeological work afford and constrain these activities.

Instead of attempting to formalise the soft system and its information flows in their entirety, it would seem that the most plausible approach for trying to make sense of the system and how it changes, is to follow the local practices of information work, identify their stakeholders and the stakeholders' worldviews. The current unspecific focus of the producers and curators of archaeological information on future research as the major stakeholder of archaeological information should be replaced by a more explicit consideration of what the research might be and what the researchers could and should be focussing on. Simultaneously, both the producers and users might benefit of thinking themselves as stakeholders and potential users of the information they are producing, and being more explicitly present in the information they are producing. Living with making and taking means that the disconnect needs to be taken seriously and accepted as a part of the ecology of archaeological information work. Living and accepting does not equate with giving up the attempts to make information as takeable as possible, or to try

to take it as closely as such as it was made whenever possible and useful. What it does mean, is that there is a disconnect that has to be acknowledged, taken into account and made explicit every time it happens indifferent of the context where archaeological information is made or used, be it in scholarly research, while telling the general public about an archaeological site, or when deciding whether to give a go-ahead for a construction project.

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