Technical Artifact: An Integrated Perspective

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Abstract. In this paper three perspectives are presented on defining the general notion of technical artifacts in formal ontologies. These perspectives share two intuitions: that technical artifacts are objects that exist by human intervention; and that technical artifacts are to be contrasted to natural entities. Yet the perspectives are different in the way they spell out these intuitions: the relevant human intervention may range from intentional selection to intentional production; and the contrast between technical artifacts and natural entities may be introduced by a constitution relation or by defining properties that set technical artifacts apart. The three perspectives are compared and their similarities and dissimilarities are explored.

Keywords. technical artifact, formal ontology, natural-artificial distinction

Introduction

Technical artifacts are all around us. We have them at hand's reach, such as chairs, at a distance, such as power plants, and at far distances, such as satellites. By this omnipresence technical artifacts have been incorporated in ontology, ranging from ontologies of specific consumer products to general ontologies for technical components and materials. From a more formal ontological perspective this incorporation leads to also including a general notion of technical artifact. But capturing the notion of technical artefact, and relating it to other notions such as that of natural entity and other notions of artifacts like social, institution, and artistic artifacts, is not a straightforward task. There are strong intuitions available about technical artifacts which may help capturing this notion. Technical artifacts are seen as objects that exist by human intervention, where this intervention involves precise reasons for selection or for production. And technical artifacts are typically contrasted to natural entities. Yet, as we shall see, there are more ways in which these intuitions can be incorporated into a characterization of what technical artifacts are.

This paper aims at a contribution to the task of incorporating the general notion of technical artefact in applied ontologies, and at addressing the relation between techni-

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cal artifacts and natural entities; the relation between technical artifacts and other types of artifacts is not addressed. The paper will bring together three perspectives on what technical artifacts are, capture these perspectives with definitions cast in a common terminology, and then compare the perspectives. The three perspectives have their origins in, respectively, applied ontology, engineering design, and philosophy of technology; throughout the paper we label the corresponding categories with *Ontological Artifact*, *Engineering Artifact*, and *Technological Artifact*, respectively. These perspectives need not represent the dominant views within their original domains, yet we submit them as giving three major ways in which technical artifacts can be understood.

The paper proceeds as follows. In sections 1 to 3 we introduce the three notions of technical artifacts, and sketch the contexts and motivations by which they emerged in applied ontology, engineering design, and philosophy of technology. Section 4 presents an integrated framework that shows several relations among the three definitions and allows us to identify where they disagree. In section 5 we take some distance from the details of the definitions and continue the comparison in a more exploratory way.

1. Artifacts in Applied Ontology

The Laboratory for Applied Ontology (LOA), ISTC-CNR, aims to develop a formal theory based on ontological analyses of commonsense reality. The perspective is well represented by the DOLCE ontology [1], a foundational ontology used in everyday scenarios as arising in social reality and in technical scenarios like medicine, product modeling, and business transaction. The DOLCE ontology is not aimed at being used as a foundation for more specialized areas like nuclear physics. The broad research goal of the LOA group requires to develop ontological understanding of a variety of general notions. Particular attention has been paid to the notions of artifact and of role since these turn out to be at the core of most entities we recognize in social reality.

1.1. Background of the definition

The notion of artifact has been studied from the perspective of applied ontology, and is therefore given as a normative notion justified by ontological considerations. The definition is formalized in first order logic by taking the DOLCE ontology framework [12,1] as the background theory but the motivations, the analysis and the overall formal system are largely independent from DOLCE itself. Indeed, the developed definition and surrounding conceptual framework is intended as a general ontology-based theory of artifacts which relies on a set of further ontological notions like agent, event, and intentionality.

1.2. Definition

The notion of artifact proposed by Borgo and Vieu is formally given in [2]. One can rephrase the formal definition as follows: *An artifact* $\mathfrak{a}$ *is a physical object which an agent (or group of agents) creates by two, possibly concurrent, intentional acts: the selection of a material entity (as the only constituent of* $\mathfrak{a}$*) and the attribution to* $\mathfrak{a}$ *of a quality or capacity.* The definition is more general than those discussed in application domains in several aspects. In particular, an artifact does not need to be the outcome of a production process. According to this view, an artifact arises when a material entity, say a pebble, is

selected (and a quality is attributed) to create a new entity, say a paperweight. The new entity, the artifact, is constituted by the selected material entity and, with respect to it, has a new distinct property, namely the attributed capacity to perform as a paperweight. Of course, produced items are classified as artifacts by the definition since the design process as well as the intentional production process are specific ways to select an entity (what is produced) as the ontological constituent of an artifact and to create the particular artifact by the act of attributing a desired capacity, namely the capacity that characterizes that kind of artifacts: a produced knife is created when a material entity resulting from intentional manipulation is selected as the constituent of an artifact and the capacity of cutting is attributed to such an artifact.

The definition refers to *material entities* as constituents of artifacts. The term material entity [2] is intended to collect both physical objects and amounts of matter since the artifact creator(s) may select a physical object, e.g., a wooden rod, to make a walking stick and a specific amount of matter, e.g., some given flour, to make dough. The distinction, in turn, allows to explain why not all artifacts are altered by the same kinds of change. For example, an artifact selected from a physical object may loose parts provided this fact does not affect the existence of its constituent; this change had different consequences if the artifact is selected from an amount of matter.

Since this paper focuses on technical artifacts, the original Borgo-Vieu definition is restricted accordingly without discussing what actually counts as technical quality or capacity:

Definition 1 (Ontological Artifact) *A* technical artifact $\mathfrak{a}$ *is a physical object which an agent (or group of agents) creates by two, possibly concurrent, intentional acts: the selection of a material entity (as the only constituent of* $\mathfrak{a}$*) and the attribution to* $\mathfrak{a}$ *of a technical quality or capacity.*

Note that the definition does not aim to describe the creation event. It simply points out the necessary and sufficient conditions for an artifact to be created and at the same time classifies it from the ontological viewpoint. The class of artifacts identified by this definition includes all the produced artifacts as well as other artifacts obtained by intentionally collecting natural resources like intentionally dug up coal, which is by no means produced. Furthermore, note that by being the result of a selection and quality attribution, the artifact is distinguished from its constituent object or material: a wooden rod and a walking stick are co-localized yet distinguished entities. Indeed, the first constitutes the second so that the walking stick does not exist unless the wooden rod exist, but not vice versa. It should also be noted that there is no claim that the artifact has that technical quality or that it performs according to the technical capacity attributed to it. A walking stick might turn out to be too weak to function as such. In this case one says that the artifact exists and is malfunctioning. Also, notice that some quality attributions are parts of a shared social perspective which justifies why the corresponding artifacts are publicly recognized as such, e.g., cars, buildings, and knives. Finally, the definition implies that the actual use of the artifact is irrelevant for its ontological status.

1.3. Discussion

This definition leaves aside the issue of describing what artifact means in, say, engineering or biology, and focuses on ontological conditions that underly the common under-

standing of the term. The goal is to isolate crucial elements, like intentionality, that must be present in order to properly understand artifacts. The basic idea is that an artifact is something existing because an agent intentionally brought it into being. In the most common examples, like cars and knives, this intentionality is part of a production process. However, the discussion of what effects a production must have on the material at stake in order to turn it into an artifact shows that what counts is the bare presence of a physical manipulation, not the effects of it. This observation leads to consider the role of the production of an artifact as a demarcation point that sanctions the creation of the artifact itself. Ontologically, it is then natural to look at the physical production as a placeholder for the ontologically relevant event of creation. Since no sensible effect can be attributed to the production itself, it is sensible to claim that the creation of an artifact is not the result of a physical act but of an intentional one which in many cases is realized via a physical production. Once the import of intentionality in the notion of artifact has been clarified, agentivity and creation find their place in the definition to ground the presence and the effect of the intentional act in the generation of the new entity. In order to distinguish the material entity from the artifact, the authors make use of the ontological relation of constitution as understood in DOLCE [12] and in the "entity stacking" technique, see [13].

Being intentionally created is however not enough to be a physical artifact. One can intentionally break a tree branch or intentionally leave a mark on a wall while strolling around. Neither the branch nor the mark are *per se* artifacts, at most one would classify them as artifactual entities. The intuition here is that the artifact created from the intentionally selected entity must bear something new with respect to the original material entity; the branch is broken so that it is (or seems to be) long enough to reach a fruit, the mark is made so to be visible to fellows. The creation of the artifact is thus motivated by the agents' intention to create something that has some given quality. This analysis shows that the creation of an artifact is more than an intentional selection of a material entity, it is the selection of an entity to generate something which is *taken to satisfy* a given quality or to possess a given capacity. Once these crucial elements are linked together, a notion has been reached that the authors propose as identifying the ontological category of artifacts. From here, one can start discussing how much this notion can be specialized to make sense of what happens in specific domains or for specific applications.

2. Artifacts in Engineering Design

The Mizoguchi Lab, part of the Institute of Scientific and Industrial Research at Osaka University, has been working since the 1990s on functionality of artifacts from an engineering point of view [10]. Function is taken as a crucial aspect of engineering artifacts. One could, however, consider functions of natural entities. For example, one might say that a (natural) stone can perform the same function of a factory-made paperweight. Such considerations led to an intuitive distinction between function of artifacts and function of natural entities, and thus to a definition of technical artifact.

2.1. Background of the definition

The notion of technical artifact developed at the Mizoguchi Lab relies on engineering design research. The main idea is based on clear distinctions between the design, man-

ufacturing, and use phases of the life cycle of artifacts. These distinctions are typically observed for engineering artifacts, but are believed to be applicable to other kinds of artifacts as well, even if some phases could be implicit for such artifacts. In addition, the design and the production phases play a crucial role to identify technical artifacts. Although the study of artifacts in engineering design has been the first motivation for the work at the Mizoguchi Lab, later the target has been extended and now the notion covers essential conditions for a wider class of technical artifacts.

2.2. Definition

The notion of technical artifact proposed by Kitamura and Mizoguchi is as follows:

Definition 2 (Engineering Artifact) *A* technical artifact $\mathfrak{a}$ *is a physical object created by an intentionally performed production process. The process is intentionally performed by one or more agents with the goal of producing the object* $\mathfrak{a}$ *which is expected to realize intended behavior in some given generic technical situation.*

The expression 'intentionally performed production process' means that the agent(s) intentionally performs the process which results in physical changes (these changes can be at the chemical or topological level as well, including assembling) from which the object $\mathfrak{a}$ is produced. The goal of the agent, for which the process is executed, is that the produced object $\mathfrak{a}$ will realize (exhibit) a specific behavior under a given situation. Under such a situation, the behavior of the artifact $\mathfrak{a}$ manifest $\mathfrak{a}$'s essential function [2] [10] since it is intended by the agent as the creator of that object. The situation of a technical artifact when its function is performed is typically given by use of the artifact. It can be categorized into two cases; (1) an artifact such as a cup is used as the whole by a user externally, and (2) an artifact such as a bolt is used as a component in a larger artifact. In the Kitamura-Mizoguchi theory [10], a function is performed in either of these situations (called 'function contexts' in that paper, for users directly or for the whole system's function, respectively). Note that by 'generic technical situation' in the definition we mean that it is not a specific situation of use but generic users' situations which are not fully specified by the agent.

Finally, object $\mathfrak{a}$ is an artifact even if it does not have the capacity to realize the behavior intended by the agent at the beginning of the production process. For example, an agent may dislike the resulting artifact $\mathfrak{a}$ and thus not select it for further processing or even trash it right after the production. Similarly a user may use the artifact $\mathfrak{a}$ differently from how the creator intended it. Such decisions of the users do not alter the artifact status of $\mathfrak{a}$.

[2] The definitions of the notion of function and the distinction from behavior have been extensively discussed in the literature such as [3,4]. In the Kitamura-Mizoguchi theory of function [10], they distinguish function from behavior based on context-dependency. A behavior is a kind of a physical process performed by an artifact as a device. A function is defined as "a role played by a (device-oriented) behavior in a teleological (function) context". Because this issue is not main for this paper, please refer to [10] for the detailed definition and discussion.

2.3. Discussion

From an engineering point of view, the manufacturing phase (and the design phase) play an important role in identifying technical artifacts. The manufacturing act is regarded as an act to embody "intrinsic" physical properties (e.g., shape, material, and topology) which are not easily changed. The definition of engineering artifact fits this naive understanding. It depends only on the production process in the manufacturing phase based on the intention in the design phase. Such production processes are also based on a structured and reasoned approach in the design phase for embodying such physical properties that realize the intended behavior.

Artifacts are independent of any other entities (as human beings are) except their parts as explained below. From the starting time point of physical existence of an engineering artifact, the object has intrinsic physical properties, in which roles intended by the agent inhere to realize the intended behavior for the intended situation. Actions in the actual use phase have no effect on the identity of the object $\mathfrak{a}$. In other words, it is independent of the actual use situation.

The possibility of use in generic situations is also important in engineering. It is realized by a design for generic use and by manufacturing acts for its stable embodiment. Thus, in the Kitamura-Mizoguchi theory, selection of an object for a specific situation is regarded as an act in the use phase. For example, a selection of a branch of a tree (or a table) for one's use as a chair is regarded as an act in the use phase and then the selected object performs as a function an accidental function which is the same as the essential function of a chair as a function [10].

3. Artifacts in Philosophy of Technology

At the Philosophy Department of Delft University of Technology a research project called *the Dual Nature of Technical Artifacts* was carried out between 2000 and 2005 [11]. In this project functions and the activities of the use and design of physical objects have been analyzed in terms of plans. Initially the focus was on *use plans* [8]; in later work on manufacturing also *make plans* were introduced [9].

A *use plan* for a physical object is a goal-directed series of considered actions, where some of the actions involve the object. The use of a physical object can then be described as the carrying out of a use plan for that object, aimed at realizing the goal associated to the use plan. Plan design can be described as the development of a use plan for a physical object or objects for realizing the specified goal. And product design can be described as giving the physical description of the objects involved in the use plan. Finally, a technical function of a physical object relative to a use plan of the object can be characterized as the capacity of the object for which (i) it is designed in product design and that (ii) contributes to the realization of the goal of the use plan when that plan is carried out.

3.1. Background of the definition

The definition of technical artifacts by Houkes and Vermaas [9] as physical objects that are produced is the result of conceptual analysis of engineering manufacturing practices and of a philosophical evaluation of the different options for defining technical artifacts

by means of the use plan analysis. The option to define technical artifacts as physical objects for which use plans exist was not adopted by Houkes and Vermaas for two general reasons. First, this option would imply that natural entities for which uses are defined – e.g., some stick and stones – would become technical artifacts as well. This implication violates the everyday and engineering distinction between natural and artificial entities, and can be taken as incoherent to the assumption that engineering is about producing new kinds of entities. Second, defining technical artifacts as physical objects with use plans would introduce a dynamical aspect to the categorization of technical artifacts – whenever an agent develops a new use plan for physical objects, those objects would instantaneously enroll in the corresponding new category of technical artifacts – and this dynamics is also something Houkes and Vermaas want to avoid.

3.2. Definition

The notion of technical artifact proposed in [9] is as follows:

Definition 3 (Technological Artifact) *A* technical artifact $\mathfrak{a}$ *is a physical object created by the carrying out by an agent (or by agents) of a make plan for an object with a physical description.*

A *make plan* for a physical object $\mathfrak{a}$ is defined as a use plan for a set of materials $m_1, m_2, \ldots$ and a set of tools $t_1, t_2, \ldots$ with the aim of creating $\mathfrak{a}$ that meets a physical description id. Carrying out a make plan for a physical object $\mathfrak{a}$, counts as producing $\mathfrak{a}$. A requirement on make plans is that one or more of the materials $m_1, m_2, \ldots$ is physically modified, or that two or more of these materials are assembled, or both. This requirement rules out that a plan to merely intentionally select an object that meets the physical description id can be taken as a make plan; such selection does not count as creating a technical artifact on this view. Make plans are developed by manufacturing engineers on the basis of the physical descriptions that are determined in product design.

Technological artifacts can be physical objects with use plans but need not be so. Chairs, Diesel engines, and nuclear submarines are technological artifacts and also objects with use plans. Transuranic atoms and the largest sandcastle on the beach made for winning the sandcastle contest of that summer are technological artifacts but not always objects with use plans. Pebbles used as paper weights and fallen tree trunks used for crossing streams are physical objects with use plans but not technological artifacts.

3.3. Discussion

With the notion of technological artifact, the set of natural entities and the set of technical artifacts are disjoint sets: an entity that comes into existence by a natural process is a natural entity and not a technological artifact; an entity that comes into existence by an agent carrying out a make plan, is a technological artifact. (There may be other types of entities, say, waste, which are the result of actions by agents but not of the carrying out of a make plan for that entity).

For an entity it is ontologically a historical fact whether or not it is a technological artifact: if the entity came into existence by an agent carrying out a make plan for that entity, the entity is a technological artifact. Inventions of new use plans do not change that historical fact. But for an entity it may be epistemically impossible to determine on

the basis of the entity's physical structure whether or not it is a technological artifact: a natural entity, such as a natural diamond, and a technological artifact, such as an artificial diamond, may have exactly the same physical structure.

4. An integrative perspective on the definitions

In this section we provide a general perspective for the comparison of the three definitions – Ontological Artifact (OA), Engineering Artifact (EA), and Technological Artifact (TA) – introduced in the previous sections. This perspective is summarized in Figure 1.

4.1. Distinguishing Technical artifacts from Nature-made Things and By-product Artifacts

Figure 1 includes the three technical artifact notions as well as two additional notions. The first of these is the notion of *Nature-made Thing* (NT), which refers to entities like rivers, valleys, mountains, and so forth, that are the result of natural phenomena like rain, water flow, and volcanic activity. The other notion is dubbed *By-product Artifact* (BA) and collects physical entities unintentionally created by agent(s), more precisely created through an action or process performed by agent(s) that was intentional but not directed at the creation of these entities; examples include footprints and waste.[3]

It follows immediately that NT and BA are disjoint categories. Furthermore, they are both distinctly separated from each of our technical artifact categories of TA, EA, and OA, since the latter three all require an intention directed at their creation. EA, as introduced by definition 2, contains entities intentionally created by agents via production processes. Something similar is true for TA, where now, by definition 3, the intentional production is spelled out as the carrying out of a make plan. Finally for OA, as given by definition 1, an intentional act of selection is involved which is absent in NT and BA.

4.2. The mutual relations between OA, EA and TA

The relationship between TA, OA, and EA is more articulated. We can see that EA is a subclass of TA, since any production process required for the creation of an EA will involve some plan guiding this process. In other words, we can think of EA as a subcategory of TA: an element of EA is a element of TA for which the make plan is aimed at a physical object that will exhibit some specific behavior.[4] As described in Section 1, an element of OA is constituted by a material entity, that is, a physical object or matter. Since each of the other four categories NT, BA, TA, and EA are themselves physical

[3]The simple definition of BA as physical entities unintentionally created by agent(s) could be taken to include in BA physical entities created by an agent through a process that does not involve an intentional action of that agent at all, such as a scratch on the wall left while turning around in one's sleep. Such entities, however, are better seen as included in NT; they involve causal activity of human bodies, but not the activity of people in their status as agents.

[4]To be sure, the definition of TA (see definition 3) also requires some physical description to be available for the object y that is the goal of the make plan. This physical description, however, need not specify a behavior that the physical object must realize. On the other hand, producing a physical object for the realization of a specific behavior cannot proceed without the availability of a description specifying how the entity will realize the behavior. This recaptures the claim that TA is a broader category than EA.

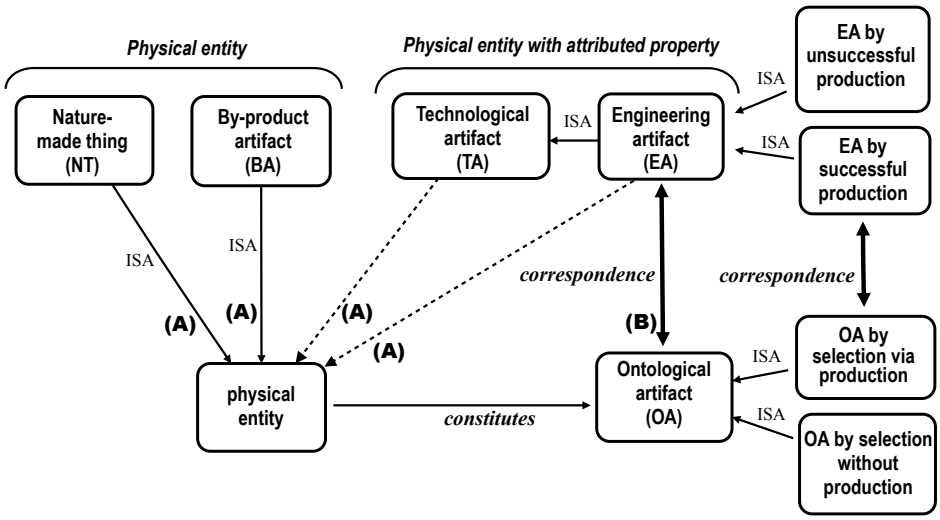

Figure 1. Relations among types of artifacts.

objects, an OA artifact can be created by selecting any object in NT, BA, EA, or TA and attributing a capacity to it. This point is, however, subtle. Both TA and EA are physical objects enriched with a new property related to the intention of the agent who produced the artifact. The selection and capacity attribution through which an OA is created runs parallel to the acquisition of the intentional property by TA and EA. What EA and TA view as the acquisition of an intentional property by a physical object is viewed by OA as the creation of a new object that is constituted by the given physical object and differs from it mainly for having the intentionally attributed property. The category of physical entities at the bottom of Figure 1 indicates physical objects when exclusively their physical properties are taken into account.[5] It directly subsumes both NT and BA, since these do not have intentional properties in addition to their physical properties. It also includes TA and EA if we strip off of these entities their extra intentional property which they received in virtue of their production. To represent this, the arrows in Figure 1 linking NT and BA to the category 'physical entity' are solid (these indicate subsumption) and those linking TA and EA to 'physical entity' are dashed, representing that for each member of TA and EA there is a correspondent member in the category of 'physical entity', being the artifact conceived of as a mere physical object.

4.3. The precise relation between OA and EA

The relation between OA and EA cannot be one of subsumption. From the ontological perspective underlying OA, the creation of an artifact is accompanied by ontological duplication: a physical object continues to exist, possibly with some of its physical properties altered, or is brought into being by composition from other objects or through the

[5]The term 'physical entity' in the figure should therefore not be interpreted as referring to the ontological category of physical entities or objects in contrast to, e.g., social entities or abstract entities. All categories presented in the figure are physical objects in that sense.

modification of material, and additionally another physical object, the artifact, which has the intentional property of having some capacity attributed to it, is brought into being. Obviously the former of these physical objects is not an EA, because it lacks the corresponding intentional property. Neither, however, is the latter of these objects an EA, because its history is essentially different: an OA comes into being instantaneously, through the mental act of selection and attribution, whereas an EA comes into being gradually, in the course of a production process. What we can say is that an ontological covariation exists between EA and OA, by which we mean that typically, to an EA, an OA corresponds, and typically, to an OA, an EA corresponds.

This covariation is not strict, however, in the following sense. It is not true that always when there is an OA, there is an EA, and neither is it true that always when there is an EA, there is an OA. The falsity of the statement that whenever there is an OA, there is an EA is a result of the fact that OA does not require any production of a physical object to constitute the artifact-to-be. An OA can come into being by a purely mental act, when an existing object is selected and made into an artifact by having some capacity attributed to it. This existing object can be a natural object or an object previously created for some unrelated purpose, as when some pebble found on the beach or a broken alarm clock is selected to serve as a paperweight. According to EA, the pebble-as-a-paperweight is not an artifact, because it did not result from a production process, and the alarm-clock-as-a-paperweight is not an artifact *as a paperweight*, since it was not produced to exhibit the behavior that is required for serving as a paperweight. From the point of view of EA, an existing EA can be changed into an EA of another kind only by intentionally modifying it to receive new properties that allow it to exhibit behavior fit for its new function. A very simple example is a match that is cut lengthways with a knife to create a toothpick.

The falsity of the statement that whenever there is an EA, there is an OA is a result of the fact that intentionally carrying out a production process does not necessitate that some quality or capacity is attributed to the produced item. The production process leading to an EA can be successful or unsuccessful. In successful production, the resulting object exhibits the behavior it was intended to exhibit. Then, from the OA perspective, the producing agent selects the entity and attributes the intended capacity to it. In the case of unsuccessful production, the resulting object is not capable of exhibiting the intended behavior. The object is still an EA, because it results form a production process that was aimed at obtaining a produced object with the capacity to exhibit this behavior.[6] In the OA perspective, however, it all depends on the intentionality related to the production process. When the production process is intended as a way to just select an entity, then an unsuccessful production does not necessarily lead to an attribution of qualities or capacities (which indeed requires an independent intentional act of attribution) and no OA need be created. When the production process is taken to correspond to both a selection and an attribution, then the conclusion of the process (successful or else) marks indeed the creation of an OA.

In summary, we have it that to each successfully produced EA corresponds an OA and to each OA selected by production corresponds an EA. This correspondence is one of two ways we can relate OA and EA, indicated in Figure 1 by (A) and (B):

[6]This reason also explains that the object created by the unsuccessful production for EA does not account as a BA.

1. start from an engineering artifact, consider it as a physical entity (via arrow (A)), select it and attribute a corresponding capacity (via the constitution arrow);
2. start from an engineering artifact (successfully manufactured) and match it to the corresponding ontological artifact created by production (arrow (B)).

An analogous relation exists between OA and TA, consistent with the subsumption of EA by TA. Since TA requires the execution of a make plan, it is not so that to every OA there corresponds a TA. Conversely, when the object resulting from the execution of the plan does not match the description informing the plan, it may not be selected, whereas the mismatch will not alter the object's status as a TA.

5. Similarities and Dissimilarities

The three notions of technical artifact discussed in this paper share the intuition that technical artifacts are to be contrasted with natural entities, but do so in a different way. Ontological artifacts OA is a category disjoint from the category of natural entities NT by a relation of constitution: the intentional act of selection of a natural entity and the capacity attribution act lead from a natural entity to a new entity, the technical artifact. Engineering artifacts EA and technological artifacts TA are not natural entities NT for a different reason: they have properties natural entities do not have.

For EA this property is the one of being intentionally produced with a goal as characterized in definition 2, and for TA it is the property of having come into existence by the carrying out of a make plan as specified in definition 3. The three notions of technical artifact also share the intuition that technical artifacts exist by human intervention, and again spell that out differently. For OA human intervention can be performed as a pure mental act. For EA human intervention is given by the intentional act of production, and for TA it corresponds to the carrying out of a make plan.

Analyzing the definitions of OA, EA, and TA in this way gives access to a wider spectrum of possibilities to introduce a general notion of technical artefact in ontology. The OA category is introduced via the constitution relation, and this could alternatively be done by considering the category of physical objects that have the intentional property of being selected for a desired capacity. Similarly the notions of EA and TA have counterpart notions obtained by adopting the constitution relation. Hence, at least six general notions of technical artifacts can now be discerned:

1. introducing technical artifacts via a constitution relation *or*
2. via an intentional property;

and, independently of this first choice,

1. via the intentional acts of selection and capacity attribution, *or*
2. via the intentional production aimed to intended behavior in some generic situation, *or*
3. via the intentional carrying out of a make plan.

The first choice of introducing technical artifacts via a constitution relation or via an intentional property represents a fundamental choice in ontology. The second choice concerning the specific intentions that set apart technical artifacts is more subtle. In philosophy of technology and philosophical metaphysics intentions related to selection of enti-

ties (for use) and intentions related to the making of artifacts are distinguished. Dipert [5], for instance, discerns three types of artificial entities by means of the intentions of the agents involved: *instruments* form the broadest type and are entities that have been "intentionally used in intentional activity"; tools form a subtype of instruments: they are instruments intentionally modified for contemplated use; and artifacts proper form a subtype of tools, being modified tools "whose modified properties were intended by the agent to be recognized by an agent at a later time as having been intentionally altered for that, or some other use." [5, pp. 24-30]. Dipert holds on to his distinctions. Hilpinen, in contrast is more lenient. He takes artifacts as entities that are intentionally made, and spells out making as physical modification, but then also allows entities that are merely expropriated for use without physical modification – his example is driftwood picked up from the beach and put on exhibition as art – as a limiting case of an artifact [6,7]. If in ontology a similar leniency is allowed concerning the second choice about introducing the general notion of technical artifact, it can be argued that some of the differences between OA, EA, and TA as introduced in this paper can be made to disappear. The difference between embracing a constitution view or not, remains present; but the difference between the characterizing intentions can be challenged. For instance, if "intended behavior in some given generic technical situation" in definition 2 is interpreted liberally as to imply that some intended behavior is associated with an entity in any generic technical situation, then the EA notion becomes similar to the TA notion. Transuranic atoms and the largest sandcastle on the beach then also have an intended behavior, namely, they are made for the aim of demonstrating that they can be made to satisfy some behavioral properties, or for winning the sandcastle contest of that summer.

6. Conclusion

We presented three perspectives on how to introduce the general notion of technical artifact in formal ontologies. We showed how the definitions of technical artifacts by these perspectives hang together and differ. From each perspective, technical artefacts form a category disjoint to natural entities but this disjointness is captured differently. It can be achieved by having technical artifacts be constituted by natural entities, or by having them made from natural entites by modification and production, bestowing on artifacts additional intentional properties, where again perspectives differ by the choice of this demarcating intentional property. Our presentation defines further work. The perspectives may be captured in more detail, and their relations can be given in more detail. A final issue is how to evaluate this plurality of perspectives. When all these perspectives are clarified enough to be accommodated in formal ontologies, the question is raised whether all should be accommodated, or only some of them.

Aknowledgement

This work has been developed within the Marie Curie EuJoint project (IRSES 247503). Pawel Garbacz was also supported by the grant N N101 150037 from the Ministry of Science and Higher Education. Yoshinobu Kitamura was also supported by Grants-in-Aid for Scientific Research (22300053) from the Ministry of Education, Culture, Sports, Sci-

ence, and Technology, Japan. Research by Pieter Vermaas was supported by the Netherlands Organization for Scientific Research (NWO).

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