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THING AND ORDER IN THE CONTEXT OF THE GLOBAL INFORMATION SOCIETY INFRASTRUCTURE

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Introduction

Relatively recent recommendations of the International Telecommunication Union (ITU) refer to the modern and evolving global infrastructure of the information society, which provides advanced services by organizing communication between things, whether physical or virtual, based on existing and developing interoperable information and communication technologies, the Internet of Things (IoT) [1]. At the same time, the term thing is understood in two ways: it is either a physical object (physical thing) or an object of the virtual (informational) world (virtual thing, for example, multimedia content or an application program), which can be identified and combined through communication networks [2]. Basic, at least – in this article, we take physical things, so using [3], we believe that "the Internet of Things is the concept of a computing network of physical objects ("things") equipped with embedded technologies to interact with each other or with the external environment".

Thus, the key element of IoT is a certain physical thing (object, thing), as this term is understood by the overwhelming majority of Russian speakers, so that the terms thing (thing) and object (object) of the English-speaking husetts" Kevin Ashton [4] have several a different meaning.

The term thing has long been used in sociology and economics, and since the time of Karl Heinrich Marx and Simon Smith Kuznets are the main element in assessing prosperity and wealth. But for the sphere of information and telecommunication technologies in 2021, of course, it is required to give a clearer explanation of this concept than that of Vladimir Ivanovich Dahl.

Further, under the thing we will mean exclusively a physical object (physical thing).

The problem statement

The opus attempts to:

- to identify signs (highlighting the main ones), which are necessary attributes of a (physical) thing as an object of IoT;
- to introduce a measure "quantity of a thing" based on the degree of ordering of the elements of a thing and allowing to compare its (potential) information power as a source of (primary) information load on IoT.

The problem solution on identifying features of a thing considered as a basic object of IoT

What sign is the main necessary attribute of a thing? Karl Heinrich Marx said that this attribute is the status of a commodity assigned to a thing, and the quantity of these things should be measured by their value (sometimes added and subtracted). Simon Smith Kuznets, in turn, offers to measure the number of things with, some debt receipts. Leaving the classics of sociology and economics in (eternal) peace, let's approach the search for an answer from the standpoint of physics. In our opinion, a thing always has a form that persists in time (more precisely, for some time). Form gives rise to a border (edge) separating the elements (atoms) of a thing from the elements (surrounding the thing) of the environment.

Example. Compressed gas in a gasholder (liquefied – in a thermos) is definitely a thing; the border of this thing is determined by the shell of the gas holder, so the shape of the thing can only be guessed. The shell itself is a separate thing. The universe is not a thing, because the set of atoms is not finite, and if so – although there is order – there is no boundary (edge), which means there is no form. And form, as we said above, is the essence of a necessary condition for a thing. The same can be said about the loss of the status of a thing of hundreds of thousands of tons of liquefied gas in the tank of the Sevmorput-3 tanker in the event of the disappearance (hypothetically) of the tank shell: the atoms remain, but the thing is not. A fraction of a substance with the approximate formula C2H5OH in 40%, by volume, in an aqueous solution, used by the hero of Alexey Maksimovich Peshkov in a slightly strange way, is definitely a thing, and its shape was set by the relief of the floor surface, the forces of gravity and surface tension.

Thus, in the world under the Moon, a thing is always in an environment, and the shape of a thing is represented by a boundary separating the atoms of a thing from the environment, and these atoms are ordered by one way or another.

The border (edge) makes one suspect the existence of a certain (maybe instantaneous or for a short time) order on the set of elements that make up a thing, and assume that this set, ordered to one degree or another, in the "ideal" is a lattice.

Thus a necessary attribute (sign) of a thing is (to some extent) the ordering of the set of elements that make up the thing. In other words, a thing is an ordered collection of its constituent elements ("atoms").

In the context of IoT problematics, order is understood in the broadest sense (the most universal, albeit far from the object, model is order, as it is understood in the theory of sets and relations: this is also the order generated by binary relations (linear, partial, etc.), and the order generated by n-dimensional relations, and etc., and etc. The order is always associated with the point (moment) of the fourth, in the sublunary world, coordinates – time. In the Cartesian coordinate world, this is a three-dimensional order (so to speak – a 3D order) generated by 3-place relations, for example: [object] (non-strict) to the left of & (non-strict) above & and (non-strict) behind [object b]. Such an order in the world always exists (at a given instant), but the "power" of order is different. The highest power (measure) of order (the degree of ordering of the atoms of a thing) is a strict (linear) order. This means, as we have already said, that there is a boundary of many atoms. And this, in turn, means that there is a form of a collection of atoms, of course – instantaneous or for a short time in the real world, as we have already said.

In addition to the ordering of atoms, there is another sign of a thing, which is the number of atoms, the power of many atoms of a thing. Measuring (monitoring) the number of atoms is a separate problem; in practice, it is customary to measure the number of atoms of a thing by the force with which the atoms are attracted to the center of the Earth (it is obvious that the things of the world under the Moon are within certain limits of the distance of the atoms of a thing to the center of the Earth).

Based on the ideas about the model of the world "from thermodynamics and statistical physicists" [5], a specific (instantaneous) thing can be interpreted as a macrostate of n its atoms. A few words about the technology of ordering n distinguishable (numbered) atoms located in the outer shell that determines the shape, i.e., we suspect that this is a thing. Let the atoms of this thing at first be in a disorderly state: almost complete chaos, the minimum degree of order, entropy – "off scale", the corresponding temperature – almost zero. The attraction and purposeful use of an external source of order (a resource for the implementation of the technology of ordering, i.e., the technology of production of a thing), the main carrier of which is energy (for the world under the Moon, it is the Sun), makes it possible to order this set of n distinguishable atoms, i.e., "Producuche" a thing (define a specific macrostate).

Let, for definiteness, the purpose of "production" is the construction of a sequence by an atom in ascending order of numbers.

There are many ways (technologies for producing a thing) of ordering n elements, among which one cannot exclude an “ineffective” technology of random (or quasi-random) search for a solution on a set of possible (admissible) solutions (the number of different (distinguishable) macrostates (different things) is the number of permutations by elements, i.e., n!). Here, the inefficiency (complexity, labor intensity) of the technology will be (as in the theory of algorithms) ascertained by the excessive number of comparison operations performed (the more these operations are performed, the more energy is spent to implement the technological process of manufacturing a thing, i.e., the less efficient the production process). In the case of simple enumeration, the maximum number of comparison operations is n • n!.

More efficient technologies are presented at the time by the unforgettable Donald Ervin Knuth [6].

The technological process of producing a thing (putting a complete order on a chaotic set), based on sorting by selection, insertion, or the "bubble method", has an order of complexity O (n2), although, of course, in the case of using these algorithms, not on a completely disordered one (as it has place in reality, because technologies for the production of things with a semi-finished product with a zero initial temperature are extremely rare), you can also get different costs of comparison operations for these algorithms. According to some estimates, the "quick sort" algorithm has the order of complexity O (nlog2 n), the merge sort algorithm has the order of complexity as O (n ln n).

The problem solution on assessing the such indicator as the number of things by the orderliness criterion

As a model of a thing as an object of IoT, we take the graph of $G = < V, U >$, where V is the set of elements, particles, atoms, bosons, bricks; U is the set of edges, that is, binary links, elements of a (binary) relation on V, giving rise to a linear order on V. In accordance with this definition, the object of the material world, represented by $G = < V, ø >$, is not a "classic thing". This object corresponds to a completely disordered thermodynamic object with a temperature of absolute zero, i.e., with
T = 0 ° K.

Example. $V = \{a,b,c\}$, $U = \{(a,a), (a,b), (a,c), (b,b), (b,c), (c,c)\}$

It can be seen that for n = 3 various options $\sum_{i=1}^{n_2}\binom{n_2}{i} = \sum_{i=1}^{9}\frac{9!}{((9-i)!i!)}$ (types, grades) of semi-finished things (raw materials, that is, material objects that are disordered in relation to the "classics", and excesses (delicacies), that is, "reordered" containing more than n*(n+1)/2 edges (binary links, elements of a (binary) relation on V, which generates a linear order on V, and hence a "classic") for the production of "classic things", where $\binom{n2}{i}$ is the number of combinations from the number of combinations of n^2 *on i , i.e.* $(n^2)! / ((n^2 - i)!\ i!)$.

You can also see that for n = 3, the number of distinguishable "classical things" is the permutation number of 3 elements, i.e., 3! = 6.

But what happens in the transition from a completely disordered set of elements to a set of these same elements, which are already called a thing?

Consider the molecular level. Here, each atom from a completely disordered set of atoms that form the "original" resource for the "production" of a thing, gradually, from "repartition" to "repartition", "overgrows" bonds (valence bonds, elements of binary relations with other atoms and other interpretations of bonds). Here the search of an answer to the question about the source of these connections, about the technology of attaching (associating) a connection to an atom, we will leave to theologians. Thermodynamists-entropists call this process as decrease in the uncertainty of *n* atoms set [5]; but if we agree that an increase of in uncertainty is equivalent to a decrease in orderliness (as we understand it in this opus), then ordering increases from molecular redistribution to molecular redistribution. Thus, if our technological process on creating a thing from n atoms is an increase in the "degree of ordering" of resource (semi-finished product) atoms set, then for "thermodynamists" the technological process of creating a thing from *n* atoms is a decrease in the "degree of uncertainty" (in terms of thermodynamics it is the decrease in entropy) of resource atoms (semi-finished product) set. By the way, as soon as the temperature (raw materials, semi-finished products, things), as physicists understand it, in parallel with the decrease in entropy rises, this indicator (temperature) is a kind of analogue of the macroeconomic indicator of GDP at the molecular level of abstraction [7].

Using the "thermo-dynamic" picture of the world (the model of world the development, the so-called "progress") allows us to draw some essential (for our problem of comparing the quantity of thing) conclusion. We are talking about an objective assessment of the dynamics of the quantity of thing, which some subjects of IoT possess. We have non-decreasing dependencies: a) temperature, degree of ordering, on the amount of connections (redistributions, elements of a binary relation on a set of n = const atoms, elements of a thing) added in the process of "moving away" from absolute cold; b) the macroeconomic indicator of GDP, on the number of added, in the process of "escape" from the absolute cold, ties by adding value at each redistribution (stage of adding a link) of raw materials (semi-finished product), bringing raw materials (semi-finished product) closer to the "classic thing". Such a "temperature" interpretation of the world (terrestrial) ordering processes, taking into account the assumption of the linearity of the existing dependencies, makes it possible to estimate the "distance" from the moment of the beginning of the (conscious) ordering of the initial physical substance to the moment when the semi-finished product (raw material for the thing) becomes "classical thing" and further ordering becomes impossible (saturation point, linear order). This distance is approximately one third of the length of the transition of n atoms from the state of absolute cold (complete disordering) to the state that we have called the "classical thing", so that technological wizards have only a third of the initial degrees of freedom to demonstrate the wonders they have ordering technologies, i.e., the efficiency of the production process (in economic and social terminology – the rate of increase in wealth, prosperity, etc., etc.). This applies to all participants in progressive (aimed at increasing welfare) transformations (production of things); however, eightfold, for some pairs of subjects of production, i.e., indirectly – physical things ([8], the technological advantage should be shown in the space of the degrees of freedom, which Ludwig Eduard Boltzmann probably cut off by two-thirds! By the way, this estimate can be used to solve one important problem, posed in general by the authors in [7], the problem of determining the initial conditions for the accumulation of physical things in order to estimate the absolute value of the number of thing, which, in turn, determines the assessment of the information load on IoT.

Conclusions

1. The basic features of a physical thing as an object of IoT are non-zero mass, the presence of form and the orderliness of the elements constituting the thing.

2. To compare the potential information capacity of sources of primary information load on IoT, it is inappropriate to use the classical (macroeconomic) measure of quantity of product to measure the indicator

of quantity of a thing, i.e., ratio [weight] • [specific value].

3. It is expedient, and from the point of view of balancing – and fair, for measuring the indicator of quantity of thing, should be considered the use of such ratio as [mass] • [specific ordering].

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THING AND ORDER IN THE CONTEXT OF THE GLOBAL INFORMATION SOCIETY INFRASTRUCTURE

In the article opus, an attempt is made to identify features that are necessary attributes of a (physical) thing as an object of the Internet of Things and to isolate basic features from them. A measure "quantity of a thing" is introduced, based on the degree of ordering of the elements of a thing and allowing one to compare its potential information power as a source of primary information load on the Internet of Things.

Keywords*: Internet of things, information load, number of things, orderliness.*

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РІЧ І ПОРЯДОК В КОНТЕКСТІ ГЛОБАЛЬНОЇ ІНФРАСТРУКТУРИ ІНФОРМАЦІЙНОГО СУСПІЛЬСТВА

У статті опусі робиться спроба виявлення ознак, що є необхідними атрибутами (фізичної) речі як об'єкта Інтернету речей і виділення з них базових ознак. Вводиться міра «кількість речі», що заснована на ступені впорядкованості елементів речі і дозволяє порівнювати її потенційну інформаційну потужність як джерела первинної інформаційного навантаження на Інтернет речей.

Ключові слова*: інтернет речей, інформаційне навантаження, кількість речей, впорядкованість.*