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New SETI prospects opened up by current information networking

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Abstract: This paper discusses ideas that impact the f_c factor as defined by Frank Drake in 1961, i.e. the fraction of planets with intelligent creatures capable of interstellar communication. This factor remains one of the most speculative terms of the equation. We suggest that the ability of sharing information is an important parameter to take into account in evaluating the tendency of a civilization to make contact (or share data) with other civilizations. Thus, we give special consideration to the fraction of planets with intelligent creatures capable of producing and sharing large amount of data. First, we determine the level of our own civilization in the framework of Sagan's energy- and information-based classification, by taking into account the recent improvements in computing and networking technologies. Second, we distinguish two types of organization, hierarchical and heterarchical, with respect to information sharing. We illustrate this distinction in the case of SETI and we show that the probability to detect a civilization would be greater if it is heterarchical than if it is hierarchical and if we utilize heterarchical principles for SETI.

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Introduction

The Drake equation attempted to formulate the number of civilizations able to communicate in the Galaxy. The last two parameters of the equation, f_c, the fraction of planets with intelligent creatures capable of interstellar communication, and L, the time during which such a civilization remains detectable, are still considered nowadays to be the two most difficult terms to estimate. The present paper focuses on f_c, and wonder whether data sharing through networks, as we do in our current terrestrial civilization, would be a relevant factor to take into account to estimate the probability of contact (or data sharing) between galactic civilizations. The Drake equation has been established considering only technologies based on radio signals. Information sciences may now provide a new approach.

Since Drake's proposal in 1961 (Drake 1961), computing/networking technologies have developed considerably. Their acceleration might be a key factor to determine whether a new civilization is now emerging on Earth and, extrapolating our case to SETI, to study the ability of a galactic civilization to share information with us. This raises the question of evaluating the present level of our civilization. The classifications proposed in pioneering papers by Kardashev (1964) and Sagan (1973) provide a way to answer this question.

The f_c factor as originally defined does not take into account the shared knowledge by a significant percentage of a civilization. This ability for sharing data is important for SETI. Clearly, a signal coming from another galactic civilization has a higher probability to be detected and deciphered if more and more complex networking technologies are developed on our planet.

In the following, we present first an overview of f_c and L factors in the 1961s context. Kardashev's classification of civilizations is also mentioned. This historical background is useful to the present analysis in order to update Earth's classification. The paper then discusses the current status of the terrestrial civilization regarding computing/information science. In the context of computing/network science, we finally discuss the heterarchy versus hierarchy network concepts and how these concepts are relevant for f_c.

A reminder of how little we know about the two last parameters of the Drake equation

During the 1961 Green Bank Conference, the factor f_c was defined as 'the fraction of extant intelligent life-forms that might have the desire and the wherewithal for interstellar communication' (Drake & Sobel 1994). Animated discussions during the meeting converged towards values for f_c between 1/10 and 1/5. The last factor L representing the lifetime of these civilizations (Drake & Sobel 1994, p. 61) was also a difficult factor to estimate. At the end of the discussion, it seemed that the lifetimes of civilizations would either be very short – less than a thousand years (with high probability of self-destruction) – or extremely long – in excess of perhaps hundreds of millions of years (Drake & Sobel 1994).

Later, Shklovskii & Sagan (1966) adopted $f_c = 1/10$. Of course, even if this value is close to 1, meaning that advanced

civilizations are not rare, it does not tell us anything about the compatibility between the civilizations themselves. Factor L might be more relevant from this point of view. Shklovskii and Sagan adopted $L = 10^7$ years, and taking into account their estimates of the other parameters, they found that the number of civilizations in our Galaxy should be around $N = 10^6$ (p. 413). This result is within the range of values proposed during the Green Bank meeting.

The Earth civilization today in terms of information and shared data

Kardashev (1964) distinguished three types of civilizations based on the order of magnitude of the amount of energy available to them, close to our present level (Type I, 4×10^{18} erg/second), harnessing the radiated energy of a star (Type II, 4×10^{33} erg/second) and utilizing the energy of a Galaxy (Type III, 4×10^{44} erg/second). Sagan (1973) proposed to add narrower gradations to fill the huge gaps between each Kardashev's Type by using a classification K (= 1.1, 1.2, etc.) based on the equation

$$K = \frac{\log_{10} W}{10},$$

where W is the energy consumption in megawatts. He defined W as the energy used for interstellar communication and estimated this power to be ≈ 10 terawatts in 1973 (he later considered that it was an overestimate). Our civilization would then correspond to a Type 0.7.

Sagan suggested adding another dimension – the information available to a civilization – and to denote it with a letter. In his classification, letter A represents 10^6 unique bits of information (less than any recorded human culture) and each successive letter represents an order of magnitude increase, so that a level Z civilization would have 10^{31} bits. He argued that we managed in 1973 up to 10^{13} bits, corresponding to letter H in his classification, making us a 0.7H civilization.

In 2013, is the Earth still the home of a 0.7H civilization? Since 1973 our energy consumption has only doubled. The Arecibo radiotelescope which sent the 1974 message has a more powerful antenna than the Evpatoria radiotelescope (Zaitsev 2006). The most powerful lasers have terawatt powers. The power we use today for interstellar communication is thus still close to Sagan's (1973) estimate.

Internet provides useful estimates of our energy and information levels. In June 2012, 697 089 482 web sites were reported by Netcraft (http://news.netcraft.com/). The total power demand in 2005 (including associated infrastructure) was already equivalent (in capacity terms) to about five 1000 MW power plants for all US servers and 14 such plants for the world (Koomey 2007), for a total $W \approx 10$ GW and a K value of 0.4. In April 2012, the encyclopaedia Wikipedia contained over 19 million articles (http://www.wikipedia.org/), and an average of 6474 new articles added every day. With 3000 bits per article this represents 57×10^9 bits. A single encyclopaedia of this size represents a D civilization according to Sagan's formula. If each server had the content of the Wikipedia website, this would represent 40×10^{12} bits. The quantity of information available on the web represents half the information the Earth civilization had access to in 1973. This is equivalent to the data shared by a G civilization.

The 0.7H civilization represents most of the people living on Earth, finding information in printed books or computers, manufacturing objects, etc. However, there is nowadays an emerging situation where more and more people manage an increasing quantity of data. Earth's civilization can be regarded as a type 0.7H, but enriched by an additional network corresponding to a 0.4 G civilization represented by the people sharing data via Internet. A 0.4 G civilization might be called 'network civilization' but a better definition may be given in the future by researchers in social sciences.

Different ways of sharing data and implications for SETI

The SETI community presents a hierarchical organization (Billingham 2002): In order to send a message from Earth such as the one sent from Arecibo in 1974, people of the 0.7H civilization needed some hierarchical organization to have access to the transmitter, to compose and agree about the content of the message and finally to get the right to send it. For instance in the case of the Arecibo message, there was no real worldwide debate about the data and information sent. The way of sharing data was then hierarchical. It is no longer the case now (Denning 2010). Technology to send messages today is indeed available for a lot of skilled people and several initiatives have already been done in that direction (Zaitsev 2006). This way of sharing data is called *heterarchy*, a term used in biological taxonomy as well as in information sciences (Crumley 1995). There would be only very few people sending messages in a galactic civilization using a strong hierarchy, whereas a lot of people would be communicating with the same rights in a civilization where heterarchy would be dominant. This point has important implications for SETI: it means that the probability to detect a civilization would be greater if it is heterarchical than if it is hierarchical (Fig. 1)

In 1997, Allen Tough designed the *Welcome ETI* website (Tough 1998). The project based on web 1.0 was to invite E.T. to communicate and share data by connecting to our Internet network. E.T. had to write HTML code to contact the team managing the website (about 100 people). It was a hierarchical organization because nobody could write a word without sending it to people having access to the server, but this technology was the only one available at the time. This experiment was unsuccessful.

Earth Speaks is a more recent project (Vakoch 2010; http://earthspeaks.seti.org/), based on Web-2.0 technology. The principle is the following: anyone on Earth can create an account on this website and write messages answering the question 'what should we respond?' (to a possible extraterrestrial message). All the messages are freely available via a map, a cloud of words or by navigating from the latest one to the earliest, without any kind of hierarchy. Once logged, everybody can evaluate each message rating it with 1 to 5 stars, thus

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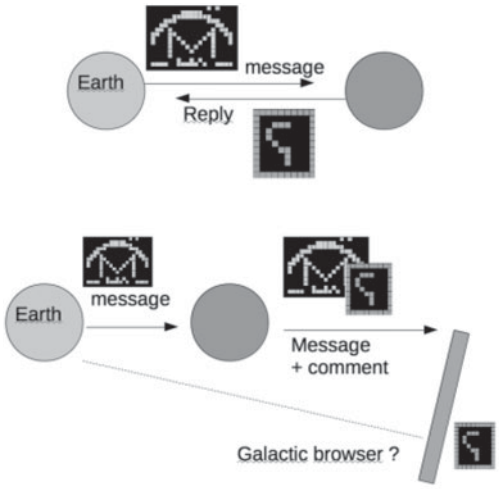

Fig. 1. Hierarchy versus Heterarchy.

answering the question 'How appropriate would it be to communicate this message in an actual transmission to an extraterrestrial civilization?'. Participants to the *Earth Speaks* messages do not need particular knowledge. They do not have to contact SETI organizations like the SETI League, the Planetary Society, the SETI Institute or the International Academy of Astronautics. This last point emphasizes the heterarchical aspect of this project with respect to the older *Welcome ETI* initiative.

A 0.7H civilization will find the *Welcome ETI* website more convenient because it can identify the authors, surf in an organized hierarchical way or print some papers. A 0.4 G civilization will appreciate the *Earth Speak* website because people will be able to easily contribute to an evaluation of its content.

Discussion

It is well appreciated that the Drake equation is a splendid tool to quantify our ignorance, even if some of the first factors are nowadays easier to estimate. The factors dealing with civilizations, i.e. technological level, evolution of techniques and civilization lifetime, are obviously the most difficult to quantify. In this paper, we called attention to a parameter related to these factors – the ability for an E.T. civilization to share information. We believe that this parameter strongly influences factor f_c (and possibly L also) and that its separate discussion does not lead to an increase uncertainty on f_c but may help to analyse it with greater precision.

In line with other authors who recently proposed to add new factors in the Drake equation (Zaitsev 2005; Maccone 2010), it would be possible to consider a new parameter representing the fraction of planets with intelligent creatures that are capable of widely producing and sharing data. Nevertheless it would certainly be difficult to have this new factor 'orthogonal' (i.e. not correlated/coupled/linked) to f_c.

An important distinction in information sharing is between hierarchical and heterarchical organizations. Heterarchy is a way of sharing large quantity of information and this could be of significant interest for SETI in several ways:

(i) Heterarchy could play a significant role in our technological development related to SETI. In passive SETI, it could provide an additional tool for detecting an E.T. civilization with Earth's instruments in the future and for deciphering its message with a better efficiency. Specialists of informatics and human–computer interface are expected to provide a greater contribution to the analysis of parameters influencing the interstellar communication.

(ii) A hierarchical civilization with only one entity (organization, leader) having the capability of producing interstellar messages will be less detectable than a civilization with many communicating entities, as suggested in this paper with the example of the new heterarchy civilization.

(iii) Heterarchy can increase the probability of receiving a non-intentional broadcast but requires technological improvements, for example a kind of galactic web browser, made of probes and telescopes exploring and scanning the sky for messages (Fig. 1).

(iv) How a civilization might react to the content of an Arecibo-type of message is not known. It is conceivable that a heterarchical 0.4G civilization receiving such a message will not send us a reply but instead will enrich it with some data or comments and then will broadcast the messages and comments in several relays using heterarchy.

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