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Science Fiction Prototypes as a Method for Discussing Socio-Technical Issues within Emerging Technology Research and Foresight

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Science Fiction Prototypes as a Method for Discussing Socio-Technical Issues within Emerging Technology Research and Foresight

Tiina Kymalainen

Abstract

This position article introduces science fiction prototyping as a thought-provoking method for arousing discussion within and between emerging technology research and foresight. The article introduces the method by demonstrating how it has already been employed within the emerging technology research domain, and how it has encouraged researchers to create science fictional stories that are based on extensive amount of research, relating mostly to their particular field of expertise. The article briefly deliberates the manner of how future studies, foresight and organizational research has already taken up and employed this method. Thereafter the article proceeds with a consideration on how foresight could further advance the future-oriented method to the unexplored fields of research that focus on the wider social, technical and economic areas of the emerging technologies.

Keywords: Emerging technology research, Foresight, Science fiction, Science fiction prototypes, Technology design.

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Introduction

This article describes innovative future-oriented research approach that has been used within the emerging technology research domain, mainly by science and engineering researchers, with the support of a method called science fiction prototyping. In short, the method aims to provide a future-oriented design outcome of the extensive knowledge gained from the emerging technology research. The emerging technologies are understood here – in the narrow but explanatory sense – covering new, under-construction technologies that pervade to the environment from the traditional desktop. Over the few decades such research agendas have been entitled as ubiquitous computing (ubicomp), ambient intelligence (AmI), artificial intelligence (AI), intelligent environment (IE) research, closing in with their latest descendant, Internet of Things (IoT) (Kymäläinen, 2015).

In many articles within this domain there have been recurrent references and side remarks associating the research with science fiction[1] films and literature. For example, Cook and Das (2007) describe the birth of ambient intelligence thus: *"Most of us have come across science fiction movies where doors opened when someone approached, or computers were able to identify the interlocutor without their name being explicitly mentioned. Some of those features were far-fetched for the technology available at the time, but gradually, some features that indicate sensible autonomy on behalf of the system were targeted by industries – and consequently, ambient intelligence was born."* Coen (1998) introduced a research project related to the Intelligent Room, entitled HAL. The project was named after the sentient HAL – Heuristically programmed ALgorithmic – 9000 computer that controls the spaceship's systems and interacts with the ship's crew in the science fiction film "2001: A Space Odyssey" (1968). In the research project HAL, Coen furnishes a test bed, akin to a combination of home and office, to support a wide range of technology administered activities. According to Coen, the science fiction film assisted in defining and exploring important elements that an intelligent environment should embrace, e.g. the necessary sensory capabilities of the environment. Another research conducted making reference to the HAL 9000 computer is introduced by Lee and Hashimoto (2002). They explain that the potential of the HAL 9000 with regard to their work lays in its high intelligence, citing its ability to observe human activity with its distributed cameras and to control subordinate systems as its expanded actuators. Lee and Hashimoto (2002) observe that this persistent association with science fiction is certainly due to forceful imageries of future worlds that provide extremely good reference points for real-world engineering.

Greenfield (2006) sees this working also the other way around, remarking that the hegemony of emerging technology research (in this case, ubiquitous

[1] Thacker (2001) defines science fiction as "a contemporary mode in which the techniques of extrapolation and speculation are utilized in a narrative form, to construct near-future, far-future or fantastic worlds in which science, technology, and society intersect."

computing) has long been apparent in the genre of science fiction. In this sense, the development of ubiquitous computing has been locked into something Greenfield calls "a co-evolutionary spiral." This means that the stories told in movies and novels have come to shape the course of the real-world invention, and these in turn serve as seed stock for ever more elaborate imaginings; and so the cycle continues. Dourish and Bell (2014), who firmly suggest reading science fiction alongside ubiquitous computing research, comment that science fiction does not merely anticipate, but actively shapes the technological futures through its effect on the collective imagination. They perceive that visions of the future shape collective understandings of the relationship between science and progress, and between people and technology, and as such have a profound, albeit little documented, impact on ubiquitous computing and its discursive practices. Penley (1997) illustrate this statement with his studies exploring the extent to which the research and engineering activities of NASA have been frequently and quite explicitly founded upon the visions of exploration and expansion embodied by the Star Trek television series. As it is, the series appears to have provided an extremely large set of referenced ubiquitous artefacts and innovations. As an example, a widely referenced artefact inspired by Star Trek was the physical form of the original communicator: the clamshell phone design and those of the early PDAs (presented e.g. by Evangelista, 2004). An example of the most commonly referenced innovation from science fiction literature is conceivably Arthur C. Clarke's (1945) speculative communication satellite.

Greenfield (2006) sees nothing new in this, saying *"science fiction merely extends the earlier tradition; folklore is replete with caves that open at spoken command, swords that can be claimed only by a single individual, and mirrors that answer with killing honesty when asked to name the fairest maiden in the land."* In his opinion, science fiction, disguised in ubiquitous computing research, is merely restaging the old tales, only this time with technology playing the central role. Johnson (2011a) explains in more detail that the symbolic relationship of science fiction and science fact stretches back across hundreds of years. He states that scientific research and technology has inspired writers to dream up compelling stories and astonishing new worlds, and generations of scientists have in turn had their imagination set on fire by science fiction stories that inspire them to devote their life to science. Johnson expands on the evolvement of science fiction by explaining a more radical movement in the 70s that formed around hard sciences (e.g. computer science, astronomy, physics and chemistry). This form of imaginative literature used either established or carefully extrapolated science as its backbone.

Greenfield (2006) remarks that creating this kind of fact-based science fiction should take a futurist immersed in the art of storytelling to take the notions and turn them into something compelling. He sees that at its best, science fiction is the synthesis of all research carried out in prototype development, compiled with other research and literature. Greenfield further highlights that the ideas and knowledge illustrated by science fiction are in fact already present in academic papers, but unfortunately, they will never touch

people outside the research communities. Bleecker (2009) continues that "productively confusing science fact and science fiction may be the only way for the science fact to reach beyond itself and achieve more than incremental forms of innovation." Callaghan et al. (2009) firmly suggest that scientists busy in developing emerging ubiquitous, ambient and intelligent technologies should put some effort into developing trustworthy and transparent tools – for without the trust of the general public in reliable sources the full potential of emerging technologies will never be realized. This is in accordance with foresight research by the manner in which Hideg (2007) has expressed a need for an expert foresight facilitator "who deals with the possible futures, their degree of desirability and inherent risks". Piiranen and Gonzales (2015) further encourage foresight discourse to build a consensus around some actionable futures, and present the need for both 'elitist' factual knowledge and participative discourse to "result in fact-based and actionable conclusions and enable forming a consensus and commitment to action."

When pursuing the definition for foresight, Piirainen and Gonzales (2015) perceive that foresight is foremost as an organized social process; an intervention that aims to create actionable and domain/context specific information or knowledge about the future. They see that foresight, as a knowledge creating activity, aims to answer to questions such as: "How can we gain knowledge about the future (or futures)?" And "What is likely to happen in the future (-s), and why?" They regard foresight methods highly as an import part when conceptualizing foresight as an organizational or social intervention. This article aims to demonstrate how science fiction may well be exploited as means to answer to these important questions Piirainen and Gonzales have proposed. In this article the prototyping activity is also demonstrated as providing a possibility to explain and predict the behavior of the socio-technical system of interest in order to give grounds to conjectures about the future.

Science Fiction Prototypes

This article discusses about the approach that has turned the co-evolutionary spiral of science fiction and fact into an actual method that Johnson (2011a) has introduced and labelled as science fiction prototyping (SFP). Johnson describes the outcome of the method, the prototypes, being "stories grounded in current science and engineering research that are written for the explicit purpose of acting as prototypes for people to explore a wide variety of futures." Bell et al. (2013) found Johnson's method laying down a rationale for the conceptual form of prototypes that "shifts markedly from the traditional prototype that expects a tangible and solid form to be presented."

Johnson considers that the science fiction prototypes work best when they are explicitly used as a step or input in the technology development process. The objective is then to employ the extensive knowledge gained from the original research in order to deliver an alternative, complementary design

outcome and explore how the research findings work in fictional experience ecologies; in contrast to studying and developing prototypes in the controlled research environments. Overall, Johnson sees the method illustrating how to interact with emerging technologies, how to study the alternative designs and business models, how to introduce new technological paths and, ultimately, how to consider the ethics and values of the technologies.

When positioned next to other methods that pursue the synergy between technology design and science fiction, within design discipline the SFP method may seem to overlap with such methods and approaches as critical design (Wolf et al., 2006), speculative design (Dunne and Raby, 2013) and design fiction (Tanenbaum, 2014). In foresight research the overlapping is mostly evident in the technological vision creating activities and scenario planning (Godet and Roubelat 1996). The most apparent difference between these methods/approaches and SFP is the framework that the method offers for the creating of the prototypes. The framework is consisted of no less than five steps, which are critical for delivering the science fiction stories as the outcome of research. The steps are:

1. Pick the technology, science or issue to explore with the prototype. Set up the world; introduce people and locations.
2. Introduce the scientific inflection point.
3. Explore the implications and ramifications of the science for the world.
4. Introduce the human inflection point with the technology; modifications or fixing the problem, the new area for experimentation.
5. Explore the implications, solution or lessons learnt.

In essence, these five steps aim to deliberate the same questions that have been found important for foresight research: when contributing to theorizing within foresight, Piirainen and Gonzales (2015) have proposed similar questions that should be asked. Those questions are proposed for the purpose of unifying the foresight research, but they may well seem to apply also to individual practices, such as the science fiction prototyping activity. The questions are:

- What factors make up the behavior of the system, why?
- Given the properties of the system, what is likely to happen in the future?
- Given the objectives, what incentives/interventions/instruments are needed to induce behavior that fill the gap from present to the goals?
- How do individual/group/organizational biases affect foresight, and how to design foresight to minimize them?
- How do individual/group/organizational perceptions affect the impact and acceptance of foresight?

For answering these questions, Piirainen and Gonzales have drawn a distinction between micro (individual behavior), meso (organizations and other groups) and macro (societies; national, or other populations) level argumentation. The challenging aspect in the science fiction prototypes is that in their socio-technical objectives they try to answer both to the broader level (which is mainly present in the original research) by deliberating the individual level (which is present in the science fiction prototypes).

Relation to Scenarios

Since the scenario creation and planning is the overlapping field with science fiction prototyping and both foresight and technology design, it seems to be in place to clarify their difference. Within foresight and strategic planning, the science fiction prototypes may indeed sound like to have a distant resemblance to scenario planning. Generally, in strategic planning the scenarios are used as devices to be employed for stimulating strategic thought and communication within companies, improving internal flexibility of response to environmental uncertainty and provide better preparation for possible system breakdowns, and reorienting policy options according to the future context on which their consequences would impinge (Godet and Roubelat, 1996).

Futures studies make a clear distinction between different attitudes towards the ideas of change, evolution or progress in societal systems. For example, Mannermaa (1991) distinguishes between the more traditional scenario paradigm and evolutionary futures research that aims to study complex, self-organizing evolutionary systems. According to Mannermaa, the scenario model has been a more or less well established branch in futures research, with much research already carried out. Mannermaa has promoted the evolutionary paradigm that assumes complexity, and conceives (the present and) the future as multiversal realities that are examined and developed through prototypes. Bell et al. (2013) firmly suggest the explicit use of science fiction prototypes for studying the evolutionary futures. In essence, they consider the main difference between scenarios and science fiction prototypes to be that scenarios act as the mechanisms for testing strategic direction, while prototypes offer a mechanism for analysis. The scenario is thus a specific set of predictions that depicts a future that could occur, and actively encourages its realization, whereas prototypes express "hope," and an approximation of the future that is a consolidation of inspiration (ibid.).

It should be noted, that the technology design, however, has taken a somewhat different approach when defining scenarios. Within the discipline, the process for creating scenarios is usually highly interactive, with all the research participants and stakeholders contributing to practice. According to Carroll (2000), technology scenarios have often been used to generate requirements, to uncover missing features, to verify and validate requirements, and to integrate the analysis of functional and non-functional, or "quality,"

requirements, such as security, safety, reliability, portability and cost. Carroll goes on to state that technology-driven scenarios have been used to support design brainstorming and prototype development, to generate issues and trade-offs in a design, and to provide usability walk-throughs for ensuring that the system features are evaluated relative to a specified context of use, design space analysis and use representations. In general, Greenfield accuses the technology-driven scenarios of decomposing all possible situations into them: every party to an interaction must be named, as well as all the attributes belonging to each of them. He believes these scenarios also neglect to model the fuzzy, indirect and imprecise behaviors; the "AI-hard" issues that surrounds us in everyday life. Buxton (2007) considers that the problem with scenarios lies in the fact that they try to tell, show, explain and convince rather than invite, suggest and question. His suggestion for changing the situation is to provide more advanced tools for users to speculate about the alternatives.

In technology design the scenario creation activity takes place at the beginning of the research process, and the outcome of the process is usually a tangible prototype or a test bed. The problem with the tangible prototyping outcomes are that, in many cases, some problems emerge with the delivery and implementation, which might be due e.g. to technical or financial challenges. Nelder (2013) has found common problems in the technology design context relating to the procurement budget cuts, bureaucracy, political intervention, long run design and development cycles, commercializing the technological innovations and the accelerating commercial technology race. According to this, one could draw a conclusion that in technology design there is a gap between what was intended and what is the outcome of the process. In technology design the science fiction prototyping has been found to be a useful instrument to fill this gap.

A Brief Synthesis on the Published Science Fiction Prototypes

Table 1 presents a brief literature synthesis on the published science fiction prototypes. The synthesis is based on primary publications that can be found from the proceedings of 6th, 7th and 9th international conferences on Intelligent Environments and Futures' issue (vol. 50, 2013) that was nominated of exploring the possibilities for the science fiction prototypes. These publication channels have been the principal publication places for most SFPs to date.

The synthesis provides a brief overview that addresses different aspects of the same phenomenon, as Deneyer and Tranfield (2006) have suggested pursuing with a review. Therefore the synthesis deliberately excludes contributions from architecture, humanities, creative arts, genetic engineering, philosophy and education, which have been some of the other issued topics within the selected publication channels. It also excludes contributions that do not follow the science fiction prototyping process or are contributing more on such methods as design fiction or critical design. The common determinant is

the emerging technology research domain, for which most of the prototypes in the SFP publication forums have contributed. Table 1 (second column) demonstrates specifically the emerging technology issues that the prototypes have addressed. The narrative approach (Cassell and Symon, 1994) was chosen to be suitable for the context as the sample of studies includes only qualitative contributions[2]. In this case, the narrative approach aims to provide a strong sense of context and orientation towards the SFP practice.

Table 1. *Literature Survey on the Science Fiction Prototypes. The SFPs Are Categorized by the Author; Each SFP is Described in Terms of its Contribution to the Emerging Technology Domain, its Background Literature and the Issues Explored*

SFP	Emerging technology research interest	Primary source of original research	Explored issues
Birtchnell and Urry, 2013	3D printing, additive manufacturing, foresight	Personal research; articles relating to 3D printing	Transformation in the manufacturing production
Callaghan, 2010, 2013	Artificial intelligence (AI), intelligent environments (IE) virtual-appliances, education	Personal research (several articles); articles relating to computing intelligence	Technological singularity; maker and hacker spaces
Clarke and Lear, 2010	Augmented/virtual/ mixed realities	Articles relating to augmented reality, technological singularity	Societal problems relating to technology control
Graham, 2011, 2013	Business models, crowdsourcing, big data analytics	Personal research (several articles); articles relating to service dominant logic, crowdsourcing	Prosumerism; complex societal problems
Johnson, 2009, 2010, 2011b, 2013	Robotics, AI, IE, black swan -events	Callaghan et al., 2000, 2009; Egerton et al., 2008, 2009; literature on Black swan –events	Free will; techno-spiritual practises; complex computational systems
Kovalchuk, 2011	Embedded systems, IE, brain computer interfaces	Personal research (several articles); articles relating to brain computer interfaces	Social space; security, encryption

[2] The narrative synthesis is more flexible than e.g. meta-synthesis; however, its limitation is that it is "an opportunistic search" and selection and therefore open to bias and misinterpretation as Cook et al. (1997) have clarified.

Kymäläinen, 2011, 2013a, 2013b	IE, Internet of Things (IoT), Cloud of Things	Personal research (several articles)	Do-it-yourself experiences; design for all
Loke and Egerton, 2010	Global sensor networks, bio-indicators, gait recognition	Articles relating to animal behavior monitoring	Environmental biodiversity
McBride, 2011	Evolutionary information systems, bio-inspired computing	Personal research (several articles)	Information complexity
McCullagh 2010, 2011, 2013	Brain computer interfaces, IE, IoT, long-term healthcare	Personal research (several articles), articles relating to IE, brain computer interfaces	Rapidly advancing technology; social and ethical issues
Nelder, 2013	Radical innovation, (enhanced hearing innovation)	Articles relating to hearing aid, hearing care	Prediction of innovation; social consequences of the technology
Peldszus, 2011	Human-space exploration, human factors	Personal research (several articles); articles relating to space psychology	Isolation in space
Scholz et al., 2011	Ubiquitous computing, wireless sensor networks, IE, (renovation)	Personal research (several articles)	Self-organizing technologies
Stahl, 2013	Foresight, organizational innovation	Personal research (several articles)	Ethical issues; privacy; intellectual properties
Tassini, 2011	Context-aware computing, natural language processing	Articles relating to IE, context-awareness, mobile applications	Technology addiction
WU and Callaghan, 2011	Artificial intelligence, brain computer interfaces, IE, nano computing technologies	Personal research (several articles), articles relating to virtual reality and mental health	Digital lifestyles; Techno-spiritual practises

As the table shows, most of the SFPs describe emerging technologies; however, their target interests evidently portray those of the conference/journal in which they are published. The synthesis demonstrates that most science fiction prototyping authors seem to base their work upon their personal research, the exceptions being Clarke and Lear; Johnson; Loke and Egerton; Nelder and Tassini. Overall, the majority of the published science fiction prototypes have focused on considering the wider socio-technical concepts and their consequences to the society, as with their prototypes the authors have written e.g. about people's complex relationship with the new technologies,

their potential effects on society and environment, change in the lifestyles of people, transposition of realities, human values, spirituality, physical and psychological health, the complexity of the systems and information overload.

Science Fiction in Studies and Foresight

When deliberating science fiction within futures studies, it should be noted, that there has also been an extensive earlier history acknowledging the influence of science fiction (e.g. Miles, 1993; Love, 2001; and Bergman et al., 2010). Love (2001) began the crusade in her short essay that introduced an anti-capitalist demonstration against robot economists who accessed to the latest global macro- and micro-economic financial information. Bell et al. (2013) however were the first to encourage the use of science fiction prototypes particularly for the study of evolutionary futures that aims to study complex, self-organizing evolutionary systems. According to them, *"most impact is achieved with views of the future that are presented as prototypical stories, which plant a seed that germinates and comes to fruition in a more distant future."* Bell et al. assume that any totalizing predictions of the future are anyhow flawed, biased and ultimately fix specific aspects of an imagined future, and justify the use of the prototypes by arguing that "a revolutionary technology defies predictions."

Consequently, a co-evolutional spiral within futures studies and science fiction prototypes had also emerged. The discipline has proposed such research approaches for studying the evolutionary futures as the event descriptions of the "black swans" (Taleb, 2007), and detecting of "weak signals" (Ansoff, 1975). The science fiction prototypes that have touched upon issues that relate to future studies, foresight and organizational research are Birtchnell and Urry, 2013; Graham, 2011, 2013; Johnson, 2013; Nelder, 2013 and Stahl, 2013 (see Table 1). In their prototype Birtchnell and Urry (2013) tackled the future of 3D printing by experimenting how the technology revolutionizes the manufacturing production, long-distance transportation and consumption. Graham (2011, 2013) issued complex societal problems and explored the use of creative fictional prototyping to motivate and direct research into new high-tech products and environments. In his prototypes Graham considered the co-creation paradigm in an online environment and the possibilities to further refine the dominant logic of services marketing. Johnson (2013) illustrated the black swan -events in his article that explored the increasingly complex computational system of an open sourced AI to a robot, Jimmy. Other authors tackled also on more specific issues with their prototypes, such as Nelder (2013) who experimented with the social consequences of the super-enhanced hearing innovation. Stahl's (2013) ethical considerations are related to privacy and intellectual properties surrounding the organizations' innovations. In this Stahl drew a reference to ETICA project, which identified eleven emerging socio-technical systems that have been found potential to significantly change the way humans interact with the world in the medium term future.

This brief narrative synthesis aimed to summarize the contemporary use of the science fiction prototyping method. The examples demonstrate that the futures studies, foresight and organizational research have already taken some concern to the science fiction prototyping method; however, there still remain many unexplored fields for research that should focus on the wider social, technical and economic topics. Birtchnell and Urry (2013) has elucidated that the usefulness of the method lies not only in fantasizing about the speculative technologies, but also in encouraging vatic insights into the possible unintended consequences and social practices emerging from people's varied engagements with technology and involvement in innovation. Schwarz and Liebl (2013) have emphasized that technological developments go hand in hand with the changes in sociocultural practices, and expect more evidence on the usage of science fiction prototypes, for example, in detecting weak signals to imagine the future.

The synthesis has hopefully provided an introductory understanding of where and how the SFP method has been used and what kinds of issues have been explored by it. It is acknowledged that the issues relating to the effect – how the method actually works – has not been meticulously or systematically studied in this or any other article.

A Rationale for the Co-Evolving Relationship

Consequently, an important contribution has been to demonstrate the science fiction prototyping method as being an important link between emerging technology research and foresight. The discussion that the paper wants to encourage is the fact that the science fiction prototyping, as a method, has the potential to contribute more on the foresight research. The co-evolving relationship between different disciplines – that could possibly be achieved by employing the method or its outcomes – seems fruitful, because foresight as a discipline holds the potential of taking a stance on the social aspects of the technology use and important issues relating to e.g. privacy, security, visibility, control, ethics, legislation and governance of the emerging technologies.

The following contains a collection of reasons and resolutions – personal insights, combined with findings from the literature research – that postulate the underlying reason for the field of foresight to take further interest on the science fiction prototyping. To sum up, within foresight research the science fiction prototypes may:

- Unfold the knowledge gained from various fields within emerging technology research
- Introduce new technologies, e.g. for defining – or redefining – what can be done with them
- Extend interesting findings
- Provide means for studying the evolutionary futures by exploiting the critical research results

- Discover weak signals associated with the studied technologies
- Study the hidden expectations and values; define the social drivers for the technologies
- Define value conflicts and their resolutions
- Study the social impact of the technologies
- Help better discuss the expectations and problems of the technologies
- Bring forth the "socially dangerous"[3] issues
- Provide means for discovering black swan -events
- Pay regard to the infrastructures and arrangements of the technologies
- Inform and generate more discussion

More than in a conventional scenario planning process the fictional prototypes may be used for considering emerging technologies and their implications within a broader web of relationships; relationships that come to the fore when interaction between people and technologies are described in detail.

It is also significant to point out that the relentlessly evolving waves of emerging technology research – and the fact that it is usually carried out behind the closed doors of universities, technological institutions and company R&D departments – might suggest that its development and advances are not at all visible to people outside the laboratories. To sum up, the conversation is important, because emerging technologies generally have more profound implications at the broader societal level, and this should be considered as one of the most important objectives when anticipating evolutionary technology futures.

Conclusions

This article introduced science fiction prototyping as an innovative method for arousing discussion within and between emerging technology research and foresight. In the introduction the article made a reference to Piirainen and Gonzales (2015), who see that foresight, principally is an organized social process that aims to create actionable and domain/context specific information or knowledge about the future. According to Hume (2006) the knowledge of the future is often based on analysis of the past and present and extrapolation of existing structures. By introducing the science fiction prototyping method – and its use within the emerging technology research – the attempt was to

[3] Mark Weiser (1995) anticipated that ubiquitous computing held qualities of something that he categorised as "socially dangerous technology." For example, in his declaration of "The technologist's responsibilities and social change", Weiser enumerated two principles for the inventors of the technologies. The first principle was: "Build as safe as you can, and build all the safeguards to personal values you can imagine." The second principle was: "Tell the world at large that you are doing something dangerous."

illustrate how this method provides possibilities to exploit "the past and present structures" and to answer to some of the profound questions in foresight.

Overall, the majority of the published science fiction prototypes introduced in the synthesis focused on considering the wider socio-technical concepts and their consequences to the society – topics that apparently are not far from the interest of the foresight research. To be critical, Greenfield (2006) has, however, formulated the problem-space of the emerging technology research as a "hundred-year problem." He refines this by saying *"It is a technical, social, ethical and political challenge of extraordinary subtlety and difficulty, resistant to comprehensive solution in anything like the near term."* That being said, the main challenge in achieving completion in any technology visions appears to lie in the holistic mind-set that will be unavoidable when the under-construction, emerging technologies are to pervade the real world. In this, foresight as a discipline could have potential to help in understanding more about the essential nature of the technology consequences.

It has been argued, the conversations about the emerging technologies are less about the future – even the near future – than about the things that exist now (Greenfield, 2006; Dourish and Bell, 2014). The final justification for employing science fiction means for foresight can be found from the critical future studies; as Hideg (2007) has elucidated: *"... the future is interpreted as something that already exists in the present in the thoughts and emotions of people. ... Future thoughts are forming and reforming in the process of discourses, so the futures existing in the present are open and humanly constructed"* (in p. 37). Nevertheless, as it has been proposed in this article, the science fiction prototyping activity holds a potential to present the "naturalization" of emerging technologies, before the technology actually exists. The science fiction prototypes of the synthesis have illustrated how the emerging technologies may become taken for granted in everyday use within their fictional experience environments. Consequently, they are then able to bypass Coleridge's paradoxical law, which dictates that: *"The effects of the technology are only visible when it has already spread and stabilized, although the shape of the technology can only be affected before it has stabilized"* (Mumford, 1964).

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