Innovation – Invention - inspiration

What the Patent Organizations and Inventors learn from technology cycles and weak signals?

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Tiivistelmä

Teknologian kehitys muuttuu jatkuvasti. On olemassa selkeä tarve etsiä uusia tapoja tuottaa ja saada “enemmän vähemmällä”. Innovaatiot ja keksinnöt antavat tähän hyvin uusia ajatuksia, mutta keksijällä pitää olla mukana myös oivallusta ja innoitusta.

Innovaatiot ja keksinnöt yhdistetään usein alkuvaiheisiin teknologian elinkaarta, ennen suuren joukon laajaa hyväksyntää ja uusien disruptiivisten ideoiden hyväksymistä.

Viimeisimpien Euroopan patenttiviraston (EPO) tutkimustulosten mukaan on olemassa selvä yhteys keksinnöillä ja talouskasvulla. Aineettomia oikeuksia omaavat yritykset vahvistavat talouskasvua.

Innovaatioiden ja erityisesti keksintöjen vaikutusten määrittäminen, mittaaminen ja ennustaminen eivät ole helppo tehtävä. Sen takia on kehitetty erilaisia työkaluja ja ennustamisen vaihtoehtoja (niin keksijöille kuin niitä arvioiville patenttiorganisaatioille). Jotkut uskovat hype – käyrään, toiset tarkastelevat innovaation ja keksintöjen kvantitatiivisia indikaattoreita. Viimeisimpinä analysoinnin apuvälineinä tulevat tekoälypohjaiset analyysityökalut. Tekniset edistysaskeleet katsotaan tapahtuvan vaiheittain, spiraalimaisesti ja jaksollisesti (esimerkkinä langattomat verkot).

Dokumentti on jaettu kolmeen kappaleeseen, joista ensimmäisessä käsitellään keksijän ja keksinnön perusasioita, sitten siirrytään toisessa kappaleessa lähemmäs keksijän ajattelutapaa, miten keksintöjä voisi syntyä, ja kolmannessa kappaleessa pääpaino on ymmärtää teknologiajaksoja patentoinnin analysoinnin kannalta.

Abstract

There is a continuous change in technology developments. There is a need to seek new ways to produce and get “more with less”. The innovation and invention provide food for thoughts, but the inventor needs also inspiration.

Innovations and inventions are most often associated to early phases of different technology life cycles and adoption, when disruptive and new ideas will be emerged.

Recent (EPO) studies have showed the clear link between inventions and economic growth. Intellectual property intensive industry boosts EU economic growth.

To evaluate and measure expectations for innovation is not an easy task, therefore tools and prediction alternatives exist (for both inventors and patent organisations). Some believe hype cycles and others have explored different ways for expectations for innovation and invention with quantitative indicators. The state of art indicators are artificial intelligence patent analysis tools. Technical advancements are happening in phases, in spiral and cyclic phases (like cellular generations).

The document is organised with three chapters. It describes basic setup for inventors and invention predictions (Chapter 1), then moving further towards inventor’s mindset, how inventions are produced (Chapter 2) and then to understand the technology cycles for patent analysis (Chapter 3).

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1 Innovation, Invention and Inspiration

1.1 Starting point

There is a continuous change in technology developments. There is a need to seek new ways to produce (materials, products, solutions, systems, methods, with less, with more efficiently and less power etc.) to get “more with less”.

Technology development can be expressed with different tools, S-curve, hype cycles, standardization levels and patenting densities (or patent landscapes). Patent analysis is a hot topic, which provides a big data analysis from how the technology area is protected, identifying “holes” and “gray areas” where no patents exist and where new technology areas may provide a new direction for patenting. It is both to understand new technology development phase, standardization status, and where the technology appears in technology development cycles.

1.2 Innovation

Innovation is both a starting point to something new, but also an interim phase and an extreme phase to something really new. The innovation can have different levels of novelty and different types of improvements.

Innovation can be defined as a "new idea, device, process, or method" [1]. It is also interpreted as “the application of better solutions that meet new requirements, unarticulated needs, or existing market needs” [1]. It can be “a commercially successful invention that changes a way of doing something” [2].

1.3 Invention

The invention can be a small step and direct continuum, an improvement from the current point, an evolution process. In the most extreme it is radically new, a disruption to something new, where there is no direct continuation from the existing phase (method, apparatus, system, computer product, etc.). The disruption is an intermittent evolution step, more like a revolution jump in a really new level of technical experience. For example, it may form a new way of achieving needed technical effect and result, e.g. with less power, materials and cost. Alternatively the emphasis is for getting a result with better efficiency, with astonishing "wow" –effect, and with better user experience.

Invention (device, method, process etc.) as a term has different viewpoints to what is its novelty degree and how big improvement steps it creates when implemented. "An invention is a new product or process that solves a technical problem" [2]. "Some inventions can be patented. A patent legally protects the intellectual property rights of the inventor and legally recognizes that a claimed invention is actually an invention" [3].

1.4 Inspiration

Inspiration is both an instant moment when an idea is emerged and a motivation fuel for pushing this idea towards something useful and working invention. With inspiration, the inventor acknowledges that there is a need or a problem exists that needs to be overcome. The inspiration directs different ways of solving the problem or finds new paths for satisfying the need. These ways may enable new innovative solutions where some results provides even new inventive solutions. The invention is said to be one percent inspiration and ninety-nine percent hard work.

1.5 Technology lifecycle, S-curve, Adoption curve

S-curve explains how innovation develops in time, and how innovation improves the performance of the new technology. S-curve can, for example, explain patent applications over time. There are different level of opportunities during S-curve phases: emerging with innovators, growing with early adopters and early majority, and maturate with late majority and saturation phases. "The dominant approach to analyzing technology lifecycle with an S-curve is to observe technological performance, either over time or in terms of

cumulative R&D expenditures. “ [5]. The innovation may jump the technology to the next level, enabling the following S-curve before current technology is matured, using so called double S-curve, as described in figure 1.

The shape of the technology lifecycle (TLC) is often referred to as “S-curve” [4].

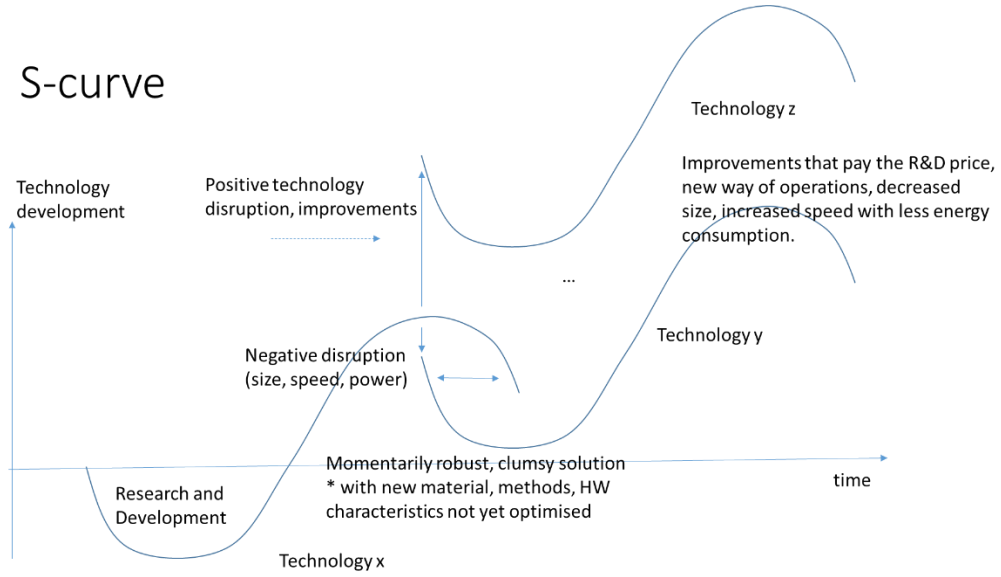

Figure 1: Double S-curve and disruption

“The technology adoption lifecycle is a sociological model that describes the adoption or acceptance of a new product or innovation, according to the demographic and psychological characteristics of defined adopter groups” [6]. Technology adoption life cycle is more like a “bell curve”, as described in figure 2, and the “bell curve” is divided into five adopter groups, innovators, early adopters, early majority, late majority and laggards [6].

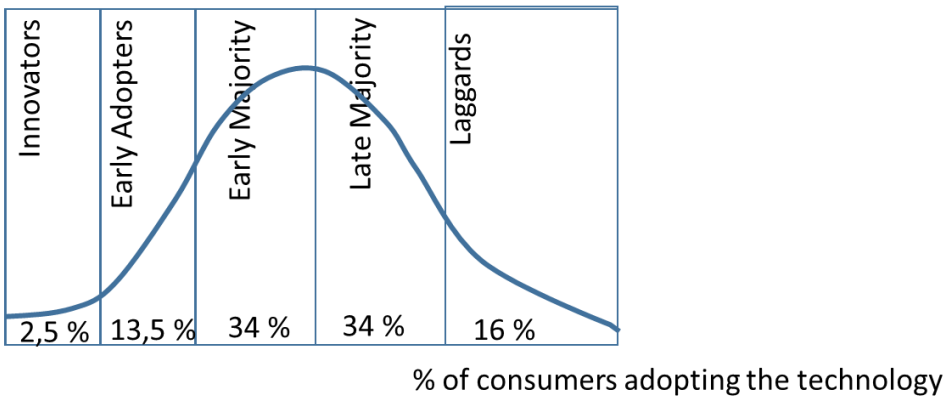

Figure 2: Technology adoption life cycle. The Rogers’ bell curve shows a cumulative percentage of adopters over time. [6]

Innovations and inventions are most often associated to early phases of different technology life cycles and adoption, when disruptive and new ideas will be emerging. "A disruptive innovation is an innovation that creates a new market and value network and eventually disrupts an existing market and value network, displacing established market leading firms, products and alliances. The term was defined and phenomenon analyzed by Clayton M. Christensen beginning in 1995" [7].

Early phases are, especially in ICT technology, time periods when joint national and international research happens between companies. This is classified as a pre-competitive period, when basic setup, systems, applications, new prototypes and engineering samples are first defined and tested together. This includes also standardization efforts, jointly defined and accepted the basic principles of global, metropolitan and short distance systems. Companies define this together, but protect alone. For example, one ICT -system (such as cellular system and its products) operating in one or multiple systems needs many commonly defined system and device parameters, interoperability parameters with other systems and interworking products and the most likely including hundreds of patents protecting companies market place.

The two first segments in the technology adoption life cycle, innovators and early adopters shown in figure 2, have time periods with full of opportunities for inventions. This is because of emerging new technology areas and new systems that has not yet been protected. There seems to be always a huge "invention race" in a certain direction, between companies, when new (potential) standardization activity has been put in place (in standardization organizations).

1.6 Technology and patent roadmap and landscape

It is often said that "most companies build their patent portfolio by protecting their current and future products. …A good patent portfolio tries to anticipate technology developed by the company but also the complimentary technology developed by other companies" [8].

When combining the IPR -strategy with the technology roadmap evolution, the patent portfolio development will focus more on those areas what has future potential impact on (people, devices, applications, services etc.) for the

company and the ecosystem. The significance could be measured, for example, with patent family densities (i.e. how many patent applications within a patent family), densities on certain technology at certain time (i.e. “hot spots” created to certain technology).

To get the technology big picture and help the IPR -strategy implementation, it is important to understand technology impact and implications in broad sense. For example, disruptive technologies form different technology and patent landscapes than evolutional technologies. Weak signals and new emerging technologies are also good inputs together with companies’ business impact and their focus areas.

There are different tools for creating patent landscape, as open source, free of charge or for a fee [9]. WIPO describes, for example, “Industry has long used patent landscapes to make strategic decisions on investments, research and development (R&D) directions, competitors' activity as well as on freedom to operate in introducing new products” [10]. The patent (landscape) map is a graphical representation of the focused patent data collection.

Technology development predictions, life cycles, provide one set of hints and technology standardizations describe another set of hints where the inventions are going, but also how does the big picture of invention landscape look like.

2 Invention: what, where and when?

2.1 What?

An inventor is naturally keen on solving problems and searching for new technical solutions. The Inventor challenges the old ideas and is able to see new ideas differently. That forms the basis for inventions and innovations. The inventor more easily understands what might be novel and inventive. He (or she) will most likely experience many obstacles and resistance against new ideas. Some of the factors give (positive) strength and some (negative) setbacks that will make an inventor and the invention even stronger, when it is progressed before patent is finally granted.

Different players, organizations and groups, have their own viewpoint to the (patent and business) topics:

- A Patenting Authority (e.g., PRH, PRV) have a legal framework (Patents Act, Patents Decree and Patent Regulations) which needs to be followed. The Authority defines whether the invention is a patent application, whether it is not obvious to a person skilled in the art, and whether it has novelty and invention steps available. The patent applications needs also to meet the requirements of industrial applicability. The Patenting Authority gives an opinion on patentability (sections 1 and 2 of the Patents Act), i.e. one or many Office Actions (OAs) with references to relevant documents. The applicant needs to reply to OA within a defined time period to keep the patenting process alive and to progress with the patent application, i.e. to correct deficiencies and argument against the references.
- A Venture Capitalist (VC), or the Business Angel (BA), needs to see, not just the invention, but also the clear business plan and strategy how the potential company will implement it and win the markets with its invention. Mostly they provide investments for startups that are starting their business and need capital push for R&D. The pending

patent application is of course a good sign for the VC to invest the company and the invention. The business potential and return of investment are important together with a set of industrial property rights (such as patents, trademarks, utility models) the company has gained or are currently in a pending phase. The key words, when implementing the strategy, where IPR strategy is one thing, are impact, significance and implications. The investor is looking for great (and innovative) ideas from the great (and motivated) startup team, where to finance and where to make profit when these become success.

- A manufacturer looks at the cost and profit, how the industrial applicable patent is possible to manufacture. They are part of the commercialization phase of the protected idea, patent or pending patent. Early prototypes help them, as well as the patent authorities and venture capitalists, to understand the idea. The manufacturer may look also at ROI, Return of Investment, for the product. The patent owner needs to decide how this commercialization part is handled, whether to follow the manufacturing path or the licensing path.
- A possible Partner may look further to the idea and invention, how to improve it. The partner invests in the idea, believes the idea, and helps its further development by providing his own expertise for the subject.
- A User, who uses the invention, being an end customer, looks at the invention again from a different viewpoint, than previous people. The user will value the patent (and the product), whether it is fulfilling the needs and whether it is solving some problems user may have. The user may focus only partly on the invention, but more on the total solution. The user will see the end results, e.g. the product, where the invention may be only a portion of the total product (or the method, the service or the process).

2.2 Where?

Inventions can emerge almost everywhere. Some of them are already invented earlier, in different or same field, or invented by the same company, with the same or other inventors, or invented occasionally at the same time by different companies. This is because companies work in the same field, follow each other, and participate in same conferences and standardization work, read the same academic and patenting achievements. With their IPR - strategy companies have built automatic and semi-automatic processes on

how to follow and get the state of art technology, market, standardization, and disruptive ideas news, which means input to their patenting and IPR strategy as a whole.

An invention will most likely feel opposition at the start, because it is too early, others won't understand its real meaning and benefit, and authorities have misunderstood its difference against prior arts when searching and providing the written opinion on its patentability. The inventor (and the patent attorney) are in a key position of describing embodiments, how the idea will work, phase by phase, and clarifying the description with clear and understandable figures. The core of the idea (found from the description) and what really will be protected and patented are the claims. It is worthwhile to pay attention to the claims structure, and have a claim strategy. Claims strategy means how to describe (broad or narrow) and what to put to the independent claims and dependent claims. The claims strategy and patent strategy are discussed in more details in [11]-[13].

2.3 When?

The inventor usually believes enthusiastically in the invented new thing, his/her own idea. The positive characteristics are positively "colored", and emphasized, whereas negative characteristics are minor, and even neglected from the total big picture. Inventors invest in the idea and prototype the patent pending idea, and provide engineering samples for business discussion after filing the patent application.

There is also a lot of uncertainty to the invention when thinking about its total life cycle. It can be part of an unknown product, without success, even though it is the great invention. The invention can be ahead of its time so much that its value is hard to estimate correctly, but by accident or by early adopters usage the word of its advancements is positively spread. The product progressiveness and disruptiveness, due to the invention, and its impact on overall technology development increase product market value. These new emerging technologies are valued with their potential to the product life cycle strategically. This also includes how well the adoption of the technologies and new opportunities are emerging (e.g. estimated in Gartner's hype cycles).

How does the inventor get the investment to the patent pending idea or to its startup company? The inventor will need to have a business plan and strategy

ready for Venture (VC) "fund raising" discussions and an entrepreneurial mindset. The good team with right mixture of different talents means a lot for VC discussions. The other feasible "fund raising" alternatives could be an initial public offering (IPO) round (when company is going public) or a crowd funding practice.

What about the IP protection? The VC and IPO round discussions don't necessarily open up inventions, so the patents are kept secret. There is also a fundraising type called "crowd funding". The crowd funding practice has a challenge with the IP protection. It describes "…ideas can be protected on crowd funding sites through early filing of patent applications, use of copyright and trademark protection as well as a new form of idea protection supported by the World Intellectual Property Organization called Creative Barcode" [14].

2.4 The invention process – the way towards the patent application

The invention process is optimally a door towards "a new world" and operating environment. This provides new approaches to old problems, solves the problems differently or changes the operational modes that bypass the problems. The original trigger for the invention could be the real need, the detected problem, and a chance, the systematical filtering of different solution alternatives or strategically improvements to the competitors' idea. The real need usually brings real improvements because someone has made effort to overcome the problem that he/she may have identified personally. When accidentally combining different context data together (if possible) the result may lead into disruptive invention jump, due to unexpected results that are interpreted differently. When touching the competitor's (potential, public, patents pending) idea, by improving or by taking into account further embodiments to this idea, the result may be unrewarding for the competitor but rewarding for the inventor (e.g. company). The competitor's idea is then "surrounded" with other patents limiting the competitor to expand (or utilize) its original idea without a license agreement, figure 3.

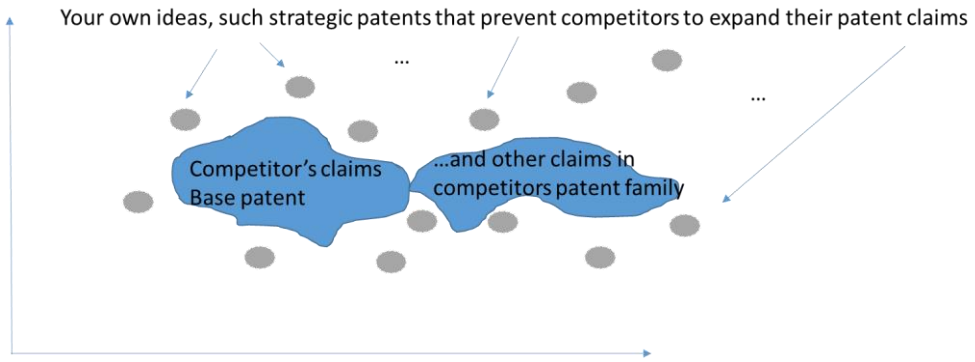

Figure 3: Claim strategy approach, surround the competitors' idea.

2.4.1 Inventor, Identify the starting point

The invention is described against known prior art, the current state of art technology. Some good ideas, that are tried to be innovative, are actually recycled, reworked and combined with a new (slightly modified) idea. This approach shows that the idea is in a way gone through innovation prescreening in the same technical field, that it is safer among users than such idea which is totally new, a risky idea, with unknown benefit. Of course, the idea is not necessarily novel or provides enough innovation steps, so it is obvious to the person skilled in the art. The real invention steps out of the comfort zone to the unknown area, to the uncertain operational area.

Inventors and innovators have "out-of-box" approach, more like a holistic view to problems that give perspective to possible results. They take intellectual risks and be as early adopters to new ideas. Inventors challenge themselves and are able to formulate possible solutions that are not obvious. They get "food for thoughts" from real life problems, and have a revolution mindset that brings discontinuities to the evolution, enabling a revolution jump in the technology development (see Chapter 3). A great idea is further refined, and technical features are processed differently. For example, the features are performed in the opposite order, with less power, and with less bits in operation. The system intelligence is distributed rather than centralized, and moved to the edge of the network etc.

2.4.2 Inventor's day

An inventor could be anyone, either by coincidently creating or systematically working towards a fresh idea that is novel and inventive. There is no

single definition for why someone is more innovative than others. The R&D -work feeds naturally new ideas, and if that reporting automatically uses invention report templates then by accident in normal reporting phase one could have described it in an invention description way.

How does the possibly patentable idea emerge? There is no clear and unambiguous answer either. There are many "sources" that feeds the idea, such as real life problems, personal experience on cross-disciplinary technologies, R&D projects, innovation projects and standardization projects.

When an idea flashes into mind, it is important to write down the key words and sketch drawings on operational modules, phases, flow charts etc. that best describes the core idea. Look at the idea holistically, what you might learn from neighboring technologies and application areas. The fresh new patentable idea may come when combining different technology areas which is not (yet) obvious. For example, an e-plant, i.e. an organic bioelectronics platform, combines two technology areas; electronic interfacing with plants. The e-plant is further discussed in [15]-[16].

It is beneficial, if the inventor utilizes in the daily R&D work common documentation approach, which is required for documenting the invention. The patent application report is then "automatically" produced by the inventor, to the same document template. The inventor then fills the R&D work content under patent application document topics, field, and prior art, and background, list of figures, summary, embodiments and detailed description of the invention. Finally, the patent claims are formulated based on above description and parts from the IPR -strategy (current and future predictions of patent scope and possible patent usage).

The inventor needs to have a clear vision for the functionality of the idea, industry applicability. The novelty features are not disclosed in any of the cited documents and are not obvious. The good way for identifying the inventive steps is to use the problem and solution approach (PSA) -method.

The problem-solution approach (PSA) –method essentially consists of three steps [17]:

1. Identifying the closest prior art, i.e. the most relevant prior art and determining the difference(s) between the invention and the closest prior art;

2. Determining the technical effect brought about by the difference(s), and that defines the objective technical problem and

3. Examining whether or not the claimed solution to the objective technical problem is obvious to the skilled person in view of the state of the art in general.

In addition to these invention process characteristics, the good IPR strategy also includes market and business aspects, such as follow, be aware of and search for prior art (patents, patent applications, non-patent literatures, other written materials) from own and competitors' products. It is also mandatory to know inside out products market and manufacturing areas and countries, ports of shipping etc. This means that the IPR strategy needs to take into account how and where to protect the idea.

How is the inventor able to circumvent the other already protected areas, claims with inventors' own idea? The simple answer is by doing protection homework carefully. The Patent Authorities have both official services and search services. The latter one is a growing service area, thanks to the digitalization of services and possibilities they offer. The search services are the ones the inventors could utilize before and after patent is filed. This includes to know what is happening in a particular field, what are competitors doing within that or neighboring fields, what are the target countries for patents, and what is the invention patentability status in that country (in those countries). This includes also how to find out if there are patents that could harm the commercial use of the product or the further development of the idea (freedom to operate report) and also to find out how strong the protection is for a patent to be licensed, or search for novelty destroying documents to revoke the competitor's patent (validity search). For example, PRH provides a tool for inventors to provide online preliminary examination of the invention. Further description can be found from [18].

The newest tool for inventors is artificial intelligence for patent monitoring and search. There are open source tools for patent analytics, free tools and commercial tools for patent retrieval and analysis. The further listings are described in [9], [19].

AI based patent search tools and language translators for patent documents are tools for both inventors and patent authorities. Patent searching results are

part of the patent network of a particular case or technology. The results can be viewed as a patent mapping, or as a patent landscape. Patent landscapes are useful if the inventor (and the patent holder) and the patent authority view the results graphically, based on various parameters such as topic densities, patent class densities, companies, competitors in this patent field, and trends etc.

The patent analysis tools are useful also for further patenting, to locate white or gray technology areas where few or no patents yet exist. Inventor may want to process and combine the patent mapping results towards new inventions. Patent analytics parameters results may be combined with new innovations, ideas, new coincidence ideas and these help to systematically harvest the potential technology area and patent playing field.

2.4.3 Brainstorming and inventions

The inventor has a creative mindset, actively seeking new ideas, trying and trying with trial and error. By exploring many ideas, e.g., with brainstorming and identifying results for a problem that needs to be solved, the inventor may finally come up to the diamond idea. Critics are not allowed and filtering is set aside during the creativity phase, i.e. the idea generation phase. Great ideas will emerge, and they are filtered gradually with different brainstorming techniques.

Brainstorming techniques produce a lot of spontaneously contributed written ideas, which are grouped, improved and extensively elaborated by the participants. The first target is to produce as many ideas as possible and the second one is to extend or add something to the presented ideas. It's important to let wild ideas to emerge. The next step is to combine and improve ideas, find their relevancies and even formulate ideas to bigger groups. The final outcome is to rank the idea clusters. The best three are often the most promising and patentable idea clusters. [20]

It is found that best ideas are discovered when the participant is outside his/her own comfort zone when exploring the technology areas where he/she is not an expert. "The ideas found during these explorations often sparked new ways to think about the work in their domain. And since they didn´t have as many preconceptions as the people in that field. They could find new uses for what were seen as old ideas" [21].

The novelty search could be useful that goes hand in hand with the brainstorming phases. This could help to quickly check the state of art, reflect it with the brainstormed idea and then clarify the patentability. It also gives improvement possibilities, and highlights how the other almost similar ideas have been built, and whether there is a possibility to bypass this obstacle (claim/claims) with non-obvious different steps or phases.

The documentation of the brainstorming phases could be organized in such a way that supports invention documentation, e.g. fill the content to prior art, figures and embodiments description. The claims will then be created from that documentation.

People who are on the other side of the invention table, the authorities, examiners and evaluators, need to take into account an interdisciplinary approach as well when evaluating the novelty and inventive steps and industry applicability. Old ideas may have been applied in a completely new way in different technology area when the technology development boost has made this possible:

- **For example, an interdisciplinary case**: "In vivo polymerization and manufacturing of wires and supercapacitors in plants", combines bio and electronics together. These "e-Plants are an organic **bioelectronics** platform that allows **electronic interfacing with plants**. Recently we have demonstrated plants with **augmented electronic** functionality. … The plant's structure acts as a physical template, whereas the plant's biochemical response mechanism acts as the **catalyst for polymerization**… using the plant's natural architecture we manufacture **supercapacitors** along the stem. … **autonomous energy systems** integrated within plants and **distribute interconnected sensor–actuator systems** for plant control and optimization" [15].

The examiner might find the similar operational description for the idea but in another technology area resembling the method of the current invention. The gap between different technology areas is decreasing, therefore it become more and more obvious to seek the results and applicable ideas from other (not necessarily neighboring) technology. The main question relates to whether this is obvious and reasonable to a person skilled in the art to combine these two technologies.

2.5 IP and economic benefits, why technology IP matters

Recent (EPO) studies have showed the clear link between an IP (intellectual property) and an economic growth. An IP intensive industry boosts EU economic growth. IPR- intensive industries contribute to EU GDP (Gross domestic product), in many ways, e.g., for business activity, employment, wages and trade. IPR-intensive industries have generated more than 42 % of the total economic activity in the EU. There is an increase of 4% from the previous study. The table below summarizes the value added by IP-intensive industries, in EU and US economies. The economic benefits of IP for Europe and US studies are further discussed in [22]-[25].

IPR-intensive industries	Share of total EU GDP (2008-2010)	Share of total EU GDP (2011-2013)	Value added, share of GDP, US economy (2014)
Trade-mark-intensive	33,9%	35.9%	34,9%
Design-intensive	12,8%	13.4%	N/A
Patent-intensive	13,9%	15.2%	5.1%
Copyright-intensive	4,2%	6,8%	5,5%
GI-intensive	0,1%	0.1%	N/A
PVR-intensive (e.g. horticulture)	---	0.4%	N/A
All IPR intensive	38,6%	42,3%	38.2%

Table 1: IPR intensive industries and share of total EU GDP and US GDP. [22]-[25].

Similar (USPTO) studies, see Table 1 above, have been made from US economy point of view, showing how the IP-intensive industry affects US economy, GDP. The recent results showed about 3.5% GDP increase in year 2014, if compared with the previous study (focused on year 2010), i.e. the share of GDP increased from 34.8% in 2010 to 38.2% in 2014.

The EU and the USPTO studies ([22]-[25]) list IP -intensive industries. For example, both chemical and ICT companies are well placed in these lists, but also industries like engineering activities and related technical consultancy, manufacture of motor vehicles, other research and experimental development

on natural sciences and engineering are part of the top 20 IPR -intensive industries, ranked as patent-intensive industries, according to their contribution to GDP.

WIPO survey on "Breakthrough Innovation and Economic Growth", year 2015, has shown that different IP rights are prioritized differently among firms across industries. "In some industries – notably, pharmaceuticals and chemicals – IP rights are central to firms' business models. In other industries, firms rely on alternative mechanisms of profiting from R&D, notably by introducing products faster than competitors and generating consumer goodwill through branding. In fact, the importance of branding highlights the indirect role that another IP form, namely trademarks, plays in fostering innovation" [26].

The breakthrough invention is something that is before the time, that is robust, possibly overlooked and underestimated by others. Its first sketches and prototypes have lot of shortages if compared to the mainstream products or current state of arts. "The myths of innovation" –book (by Scott Berkun) points out "New ideas demand new perspectives, and it takes time to understand, much less judge" [21]. The inventor may gain further when taking the holistic view, looking from a "helicopter view", turning the idea and its features upside down etc.

There are many ways to seek the great idea and potential invention, as has been described before. The technology cycles and prediction tools are useful tools for understanding possible patent applications. These facilitate and catalyst the invention way towards successful granted patent, as will be described in the next chapter (Chapter 3).

3 Technology cycles

3.1 Technology success and patent analysis

Patent data offers an instant view of technology trends that are showing the technology diffusion. It provides more confidence for companies owning the patent rights, forming the state of art criteria for next novel ideas and showing that the company R&D project bore fruit (when patent was granted). The patented idea offers credibility to the owner, an asset for technology transfer negotiations and provides importance for other company negotiations, such as licensing and other technology trade negotiations. This is because the idea has been processed and passed by neutral authority (national or international patent authority) and the great idea survived through various Office Actions and patenting negotiations.

There is a lot of literature discussion on how patent is used for forecasting the technology success with different prediction methods. "Patent data may be used to predict the success of technology when analyzed in the context of technology life cycle (TLC), diffusion potential, and technology scope (patent power and expansion potential)" [27]. Some patent forecasting studies utilize patent citation, weighing, S-curve, associations and time series analysis etc., to predict the importance of the selected criteria.

Theme	Details
Frequency Analysis	Filed country, Inventor, Applicant, Technology Classification ..
Share Analysis	Filed country, Inventor, Applicant, Technology analysis, Detailed technical classification ..
Time Series Analysis	Application rate analytics , National analysis, Inventor analysis, Applicant analysis, Technical analysis, New applications analysis, New inventor analysis ..
Correlations	Inventor correlation map, Applicant correlation map, Technical correlation map ..
Citation Analysis	Citation relation analysis , Core patent analysis ..
Rights Analysis	Patent family map ..

Figure 4: types of patent analysis [29].

To evaluate and measure expectations for innovation and invention is not an easy task, as said before, therefore tools and prediction alternatives exist. Figure 4 lists few types of patent analysis, which give specific details according to IPR strategy needs. Some believe hype cycles and others have explored different ways for expectations for innovation with quantitative indicators such as "the number of participants, the number or the ratio of the technological innovation documents, patent statistical data and the search flow of Google and other search engines" [28].

3.2 Hype cycle, what it means

New emerging technologies can be evaluated and analyzed in many ways, e.g. based on their weight, expected value, impact, problem solving value. For example S-curve, Gartner hype cycles, "top ten hot trends". They all give a hint to recent innovation activity, previous inventions, R&D, new openings to technology directions.

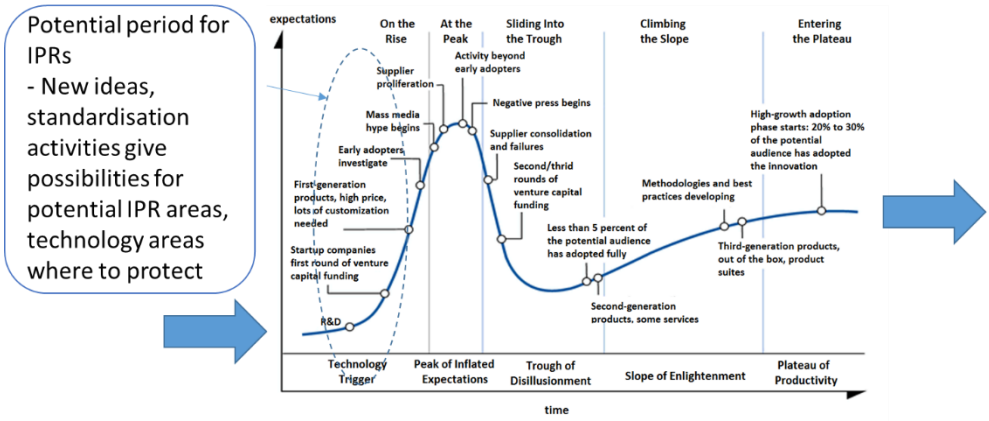

Figure 5: Hype cycles: Hype cycles explained [30]. The technology trigger period is potential period for IPR.

The potential period for IPRs is within those early adopters and innovation triggers time periods. During this period, there is R&D ongoing, startup companies (and others) are trying to raise the fund for next R&D round. First-generation products with lots of customization also appear. There are some indications for mass media hype to start. It is good to understand opportuni-

ties of this period and the link between standardization and intellectual property rights (IPR). Those pioneers and early adopters have a moment to win already at this innovation (technology) triggers phase. This is because it is a new IPR area, there are lots of possibilities and no invention yet, i.e., it is good occasion for those who discovered this to start inventing and protecting all ideas. The new emerging technologies (and the new openings) will come up and patenting activity is immediately increased (or even before with the early pioneers). The new opening provides a new patenting field, with less or no invention for a start. The patenting field is full of holes if compared with the saturated technology area. It also triggers the standardization phase as companies need common rules.

Standardization effort is another sign for potential period for patenting. It forecasts quite reliably where the next patenting field and patentable topics will emerge. The standardization timetables also drive patent applications order, features that are under discussion in standardization work packages. For example, ICT -technologies are developed in many standardization organizations that focus on certain technologies. Some of them has gained a momentum to become a brand technology (e.g. Bluetooth, WLAN, cellular, Ethernet technologies), where more innovations and inventions more often emerge.

As stated in an older study (2004) on standardization and IPR, "Standardization strives for the diffusion of technologies in the public interest, while intellectual property rights aim at secure private property protection. Obviously, standardization and the protection of intellectual property serve different objectives. However, they have to co-exist in the same industrial and commercial environment, but also in the research framework programs" [31].

The study ([31]) concluded how IPR and standards interrelate with each other:

a) the two are designed to complement each other, which promotes a 'virtuous circle' of creation and diffusion of new knowledge,

b) in the worst case, IPR, especially patents, can be exercised to block standards

c) and however, in a growing number of cases there is a need to ensure more efficient licensing mechanisms, for example through equitable patent-pool

schemes, which do not endanger the IPR regime, but allow their controlled diffusion into standardization processes.

There are two types of IPRs: standard related IPRs (i.e. essential patents or standard-essential patents) and implementation related IPRs. For common systems (to interoperate with different products) the standards needs to be developed together and needs IPRs from many companies. This has put in place the need to have a common framework for how to utilize the standard and that those standard patents are not blocking the usage of the common standard. Therefore usually the standard patents are licensed between companies participating in the standardization effort. Standardization organizations have reasonable license schemes developed, such as RAND, RAND-Z.

The most common license schemes are "reasonable and non-discriminatory terms (RAND), also known as fair, reasonable, and non-discriminatory terms (FRAND), denote a voluntary licensing commitment that standards organizations often request from the owner of an intellectual property right (usually a patent) that is, or may become, essential to practice a technical standard" [32].

"Standards bodies face the challenge of ending up in situations whereby patent owners would not be willing to license other parties that want to adopt the standards. This is especially troublesome for the so-called 'essential patents': those patents that are indispensable in order to make products that comply with the standards, because there are no alternative means to do so. …Over time, the number of patents notified under FRAND policies has grown strongly" [33]. When building and operating with a wireless product, the one needs a lot of both licensed and its own differentiator patents. For example, in mobile telephony standards there are a lot of patent owners, which have mandatory essential or optional essential patents. Those are the patents that are needed for fully operational wireless standard related products. It is important to understand "whether the claimed essential patents are also the technically most important or valuable patents in the particular field of technology. Whether this is the case will depend, among other things, on the technical inclusion process: on the basis of what considerations do the committees that draft standards include patented technology?" [33].

It is important to know that "'technology inclusion' process give firms a number of opportunities to drive patents into a standard. Once the standard is established, firms may adopt a diverse set of further strategies for exploiting these patents and obtaining access to others' parties patents, where necessary" [34].

Patent process and standard settings processes work hand in hand. As reference ([35]) describes, an inventive idea is a part of the new problem to be solved by R&D and it contributes to standard settings requirements. When invention is declared and patent application filing is under preparation, new standard revisions are developed and in process. When patent prosecution is happening, e.g. in national or in PCT phase, it gives solutions to a standards definition process and vice versa as the standards definition process gives ideas for new invention amendments and patent claims.

On the other hand, implementation related IPRs are those where the owner of the IPR makes money, if the implemented solution is beneficial and customers have adopted it widely.

The first real products are a few years behind the patent process. This not necessarily the case, as patenting and product development happens concurrently nowadays. The patent application is filed and is processed within its own timetable, as it is dependent on the patent authority response time and applicant response and argumentation time. The product is developed with either the "patent pending" or "patent xyz" remarks, in parallel. The granted patent protects a method/an apparatus/a computer program product comprising a claimed technical feature set.

The patent application will get input from recent new ideas and technical achievements from others, from raised needs and problems, from competitors follow up information, from new products in the market, from applicant's own strategy changes and emphasis, from standardization work package work phases, from raised unexpected events and problems that need to be solved. Even the extreme example could be improvements invented from recent others patent applications, where the current invention gives "food for thoughts"

for new ideas that have not been solved or taken into account by previous patents.

The patent application will go through many internal phases, filtering or idea iterations within the inventor's thoughts and companies patenting processes. The company's IPR -strategy matters what to prioritize and what to apply as a patent.

3.3 Technology waves and cycles

The technology and technology areas seem to be developed in bursts, the progress is shown cyclically, e.g., in ICT technology areas. The development is also shown as technology waves, e.g. wide area networking generations in cellular waves: NMT->GSM/2G->UMTS/3G->LTE/LTE-A /4G -> 5G, and metropolitan area networking wave (IEEE802.16, WIMAX) and local area networking (Ethernet, optical access networks, WLAN), personal area networking (NFC, Bluetooth). For example, when one cellular wave (up and down) is explored and invented thoroughly (for particular revision), the results may be applied to the next networking level, i.e., metropolitan area networking wave, and after that useful ideas to the next shorter networking wave, i.e. wireless local area networks, WLANs.

Technology cycles in ICT

Technical advancements are happening in phases, in spiral and cyclic phases (like cellular generations), as described in figures 6 and 7. The quantum leap, from one level to the other, needs both improvements in basic technical phenomena, physical characteristics and the real disruption jump, like speed improvement in 10x or modulation improvements, as well as security and privacy improvements.

New technology generation (i.e. jump to the next level in a spiral and cyclic development) is possible when core operational parameters and mandatory features are improved. For example, for ICT-systems, this means that there are better physical interface characteristics (i.e. RF, MIMO, antenna, modulation, channel coding, error corrections), link layer operations (i.e. protocols, data and control frames, data bridging, routing, switching, quality, OAM features), processor (speed, power consumptions), memory characteristics (type,

storage capacity), security (encryption and decryption), coding (voice and data) and privacy aspects etc.

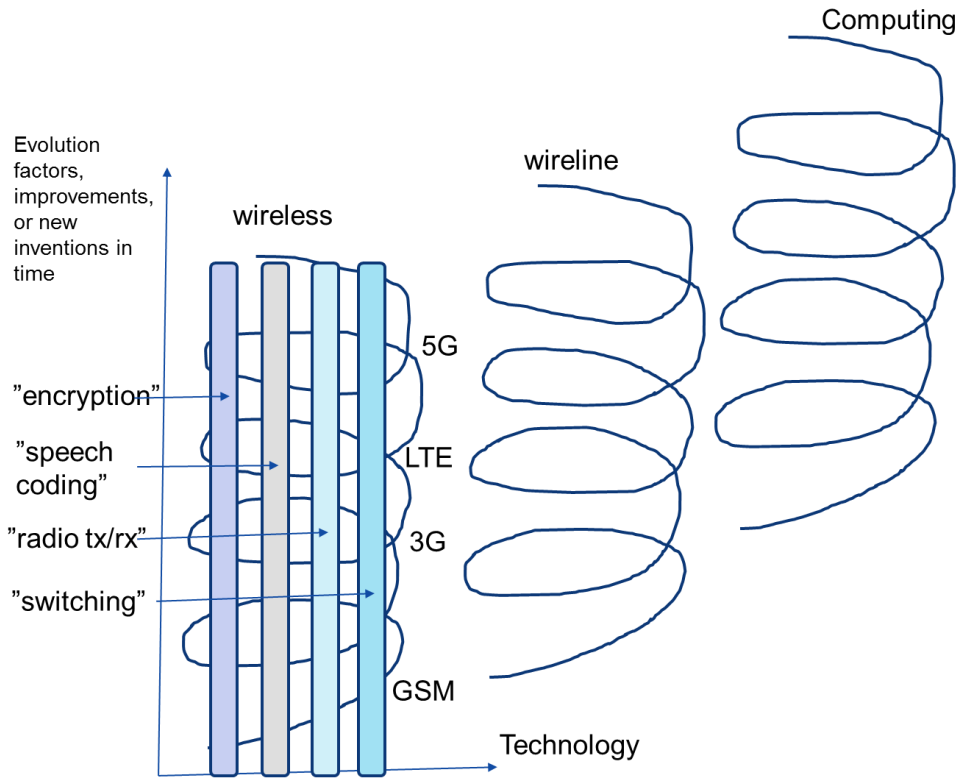

Figure 6: technology development happens in spiral cycles.

The disruption jump, with patents, needs both to open and combine previous solutions features and functions differently (and with added new features). This includes a new approach for conventionally associated to certain OSI layers, when exploring new ways to operate systems faster, with less power, with new applications supported and reducing unnecessary parts, certain OSI layer functions. This also means that some functions are now distributed (when previously centralized) and filled with intelligence into a system module (when previously a dummy module) and move to the edge of the network (when previously in the core system). For example, building blocks technologies (X-axis), like materials, radio tx/rx, modulation, encryption, speech coding, switching are continuously improved (Y-axis) and which are jumped to the next performance level of the spiral, as shown in figure 6. New technical solutions (e.g. in wireless systems, like GSM->3G->->LTE->LTE-A->5G) are found when new inventions are created. Their inventions follow the spiral technology development phases. Most of the building blocks needs to be well improved for the total solution (wireless solution x) before spiral turns to the next level, the next spiral. There is also an input from standardization

organization that prioritize the work items giving the input and direction to the spiral development.

Technology waves in ICT

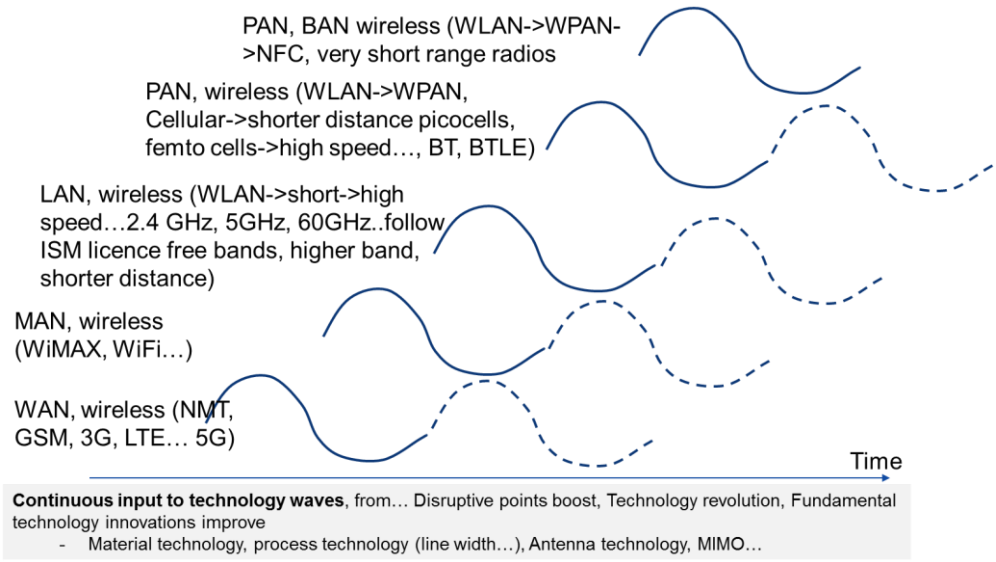

Figure 7: ICT innovation happens in technology waves

Technology waves follow the distance "rules", as described in figure 7. First wide area networks were improved, then companies focused putting metropolitan level networks into better shape, after that they jumped for developing the local area, access and personal area networks. When the cycle was done once, the next improvement cycle returned back to the following generation of wide area network development (GSM->3G->4G->5G). It was inevitable that sequential improvements were not enough (WAN->MAN->LAN->PAN), therefore parallel improvements became more suitable (i.e. improve the networks in pairs, the whole chain for certain applications and services etc.).

Certain standardized technologies are accepted better than others. These technologies have become more like "a brand" than just a technology, which helps them to become dominating technologies and which also reflects patenting activity as well. Such brands are easily identified, for example Ethernet (IEEE802.3 family), TCP/IP (IPv4, IPv6, IETF), WLAN/WIFI (IEEE802.11 family), cellular technologies (2G, 3G, LTE, LTE-A, UMTS, 4G, etc. revisions).

3.3.1 Technology monitoring and patents

Why do certain inventions happen in clusters and within the same time? It is because of companies R&D and standardization collaboration activities. No one is able to research, develop and invent alone and to take all aspects into account, to make interoperable and working system. The interoperable system needs common interfaces, rules and policies, therefore standardization is important. Another reason is also because of the prerequisite for achieving the next technology level is gained at the same time, from previous systems, e.g. cellular systems backward compatibility. The knowledge is accumulated (to inventors and others in time) within the society along with technical achievements and technical developments. Therefore certain inventive steps are happening at the same time at different places (without knowing each other's invention). The patent landscape and artificial intelligence patent analysis tools show the concurrent inventions densities in time, in many companies at the same time with the same topics. The technology monitoring is therefore important for both inventors, companies in that field and for patent authorities as well.

4 Conclusion

There is a continuous change in technology developments. There is a need to seek new ways to produce and get “more with less”. The innovation and invention provide food for thoughts, but the inventor needs also inspiration.

Technology development and life cycles can be expressed with different tools, S-curve, hype cycles, standardization levels and patenting densities (or patent landscapes) etc.

Innovations and inventions are most often associated to early phases of different technology life cycles and adoption, when disruptive and new ideas will emerge.

Inventions can emerge almost everywhere. Some of them are already invented earlier, in different or same field, or invented by the same company, with the same or other inventors, or invented occasionally at the same time by different companies. This is because companies work in the same field, follow each other, and participate in the same conferences and standardization work, read the same academic and patenting achievements.

To evaluate and measure expectations for innovation is not an easy task, therefore tools and prediction alternatives exist. Technical advancements are happening in phases, in spiral and cyclic phases (like cellular generations). New technology generation (i.e. jump to the next disruption level) is possible when core operational parameters and mandatory features are improved.

The patent landscape and patent analysis tools show the concurrent inventions densities in time, in many companies at the same time with the same topics. The technology monitoring is therefore important for both inventors, companies in that field and for patent authorities as well.

5 Abbreviations

BA: Business Angel

BAN: Body Area Networking

BT: Bluetooth

EPO: European Patent Office

FRAND: fair, reasonable, and non-discriminatory licensing terms

GDP: Gross domestic product

ICT: Information and Communications Technology

IEEE: Institute of Electrical and Electronics Engineers

IETF: Internet Engineering Task Force

IPO: Initial Public Offering

IPR: Intellectual Property Rights

ISM: Industrial, Scientific and Medical –radio frequency band

LTE: Long Term Evolution –wireless

MIMO: Multiple-Input and Multiple-Output

NFC: Near Field Communication -wireless

OA: Office Action

OAM: operations, administration and maintenance

OSI: Open Systems Interconnection Reference Model

PAN: Personal Area Networking

PCT: Patent Cooperation Treaty

PSA: problem and solution approach

PRH: Finnish Patent and Registration Office

PRV: Swedish Patent and Registration Office

R&D: Research and Development

RAND: reasonable and non-discriminatory licensing terms

RF: Radio Frequency

ROI: Return of Investment

TLC: Technology lifecycle

UMTS: Universal Mobile Telecommunications System

USPTO: United States Patent and Trademark Office

VC: Venture Capitalist

WIMAX: Worldwide Interoperability for Microwave Access

WLAN: wireless local area network

WIPO: World Intellectual Property Organization

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