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An Empirical Analysis of Hype-cycle: A Case Study of Cloud Computing Technologies

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Abstract: Gartner consulting analyst observed that promising new technologies seem to go through a predictable pattern in the early stage. The pattern is positive hype and negative hype caused by high user expectations and disappointment occurred respectively. Existing research literature on hype-cycle fails to provide sufficient consideration for theoretical frame and empirical verification. This paper provides an empirical validation for the hype cycle. Many investigators are reported that cloud computing is disruptive or transformational technology. Hence for case study we have considered cloud computing deployment models, service models and sub-technologies. This paper presents the hype cycle of cloud computing technologies using news articles and compared with Gartner hype cycles. This paper also investigates the correlation between hype cycle and life cycle of cloud technologies.

Keywords: Cloud computing, Hype-cycle, Life cycle, Gartner hype-cycle.

I. INTRODUCTION

In 1961, a computer scientist, John McCarthy, predicted that "Computation may someday be organized as a public utility". But due to unavailability of required infrastructure and development models, cloud computing remains in conceptual form for approximately 30 years. Cloud computing is the megatrend in the IT world which offers resources and services over the Internet. Cloud computing is a buzzword in industry. This new paradigm is quickly attracting a number of customers due to pay per use model, scalability, dynamic resource provisioning etc. Enterprises, governments and customers are planning for investment and support for cloud computing. It creates a need to investigate correct time for investment in the area of cloud computing.

We have seen many technologies which gone through a phase of over-enthusiasm followed by phase of disappointment occurred due to unrealistic expectations about the technology. Technology may become obsolete in this phase. The hype cycle model explains technology progress with respect to user expectations or visibility of the technology. Technology hype cycle method focus on expectations of users. Technology hype cycle model is used to explain the process by which the expectations regarding the technology evolve and the process by which the technology becomes established in the market and utilized by companies [1].

Gartner hype-cycle provides a graphic representation of the evolution of visibility, maturity and adoption of specific technologies as a function of time. Objective of hype-cycle is to provide an insight to decision makers for right strategic decisions by understanding the technology evolution. Gartner technology hype cycle is a popular and effective method to identify progress of technologies [1]. Gartner has published hype-cycle for different technologies such as mobile and wireless networking [2], XML [3].

Hype-cycle model has not been mathematically defined properly. The empirical and theoretical justification of Gartner hype cycle is a very relevant open question in the field of technological life cycle analysis [4]. The primary objective of this paper is to provide empirical validation for hype-cycle. The results are compared with Gartner hype-cycle for cloud computing. Second objective of this paper is to analyse cloud computing technologies using hype-cycle. The hype-cycle of cloud computing deployment models, service models and sub-technologies presents comparative analysis of progress of technologies with respect to visibility.

II. HYPE-CYCLE

Several technology life cycle models attempt to determine the evolution of a technology. The two most popular are the performance S-curve and the adoption curve. Adoption curve model focus on by the purchasing behaviour of users. Technology S-curve model considers the technological / performance growth of the technology. Gartner's hype-cycle model adds another dimension to technology life cycle analysis. It characterizes the typical progression of an emerging technology from user and media over enthusiasm followed by disappointment and understanding According to Gartner, hype-cycle means graphical presentation about maturity, adoption and business application of a technology. Gartner's hype-cycle is introduced in year 1995. Hype-cycle is most important product which is released annually.

A. Phase of hype cycle

Hype-cycle is divided into five distinct phases: innovation trigger, peak of inflated expectations, through of disillusionment, slope of enlightenment and plateau of productivity [5].

Figure 1 shows the phases of hype-cycle.

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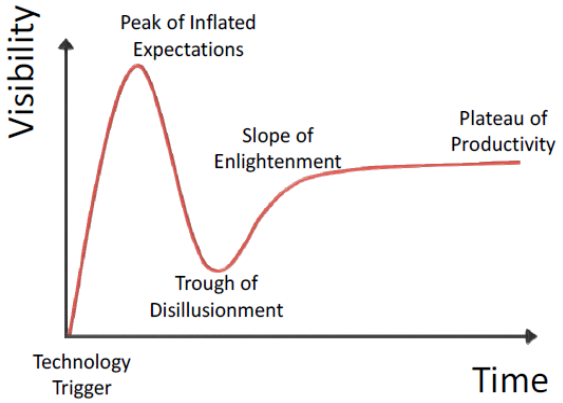
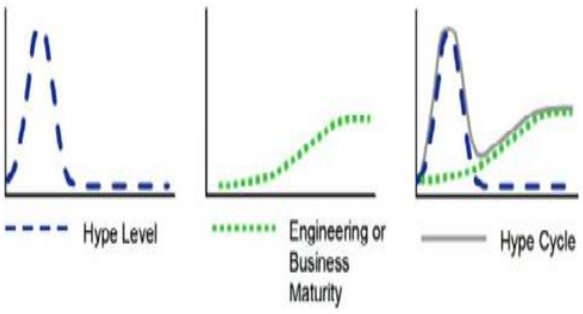


Fig. 1.Technology Hype cycle

The description of hype-cycle phase give by J. Fenn [6] is as given below,

Technology Trigger: A breakthrough, public demonstration, product launch or other event generates significant press and industry interest.
Peak of Inflated Expectations: During this phase of over-enthusiasm and unrealistic projections, a flurry of well-publicized activity by technology leader's results in some successes but more failures as the technology is pushed to its limits. The only enterprises making money are conference organizers and magazine publishers.
Trough of Disillusionment: Because the technology does not live up to its over inflated expectations, it rapidly becomes unfashionable and the press abandons the topic.
Slope of Enlightenment: Focused experimentation and solid hard work by an increasingly diverse range of organizations lead to a true understanding of the technology's applicability, risks and benefits. Commercial off-the-shelf methodologies and tools become available to ease the development process.
Plateau of Productivity: The real-world benefits of the technology are demonstrated and accepted. Tools and methodologies are increasingly stable as they enter their second and third generation. The final height of the plateau varies according to whether the technology is broadly applicable or benefits only a niche market.

B. Theories behind hype-cycle
Fenn and Raskino [5] argue that three human nature phenomena are responsible for the curve's shape:



(a) (b) (c)

Fig.2. the two curves that form the hype cycle (taken from [7]).

attraction to novelty, social contagion and heuristic attitude in decision making.

Figure 2 (a) shows the bell shaped curve showing positive and negative hype due to initial high expectations followed by disappointment from users. Expectations rise quickly and are easily frustrated. It describes first three phases of hype cycle innovation trigger, peak of inflated expectations, through of disillusionment.

Figure 2 (b) shows S-curve that describes the nature of innovation. The stages from the trough of disillusionment to the plateau of productivity are also known as the technology life cycle or the S-curve, which describes the introduction, growth, and maturation of innovation and technology. The hype level curve and technology s-curve together form the hype-cycle [5].

C. Speed of technologies through Hype-cycle phases
Technologies do not move at a uniform speed through the hype-cycle. It often takes years for a technology to traverse the hype-cycle. Some technologies may take decades. There are three adoption speeds.
Fast-track (2-4 years): Technologies go through the hype-cycle within two to four years. This occurs when the performance curve inflects early in the life cycle of a technology. Fast-track technology indicators include: high value, simplicity of use by enterprises and users, several strong vendors that support the technology, use of the current infrastructure, a rapid transition from consumer to corporate use.
Long-fuse: Technologies may take one or two decades to traverse the hype-cycle.
Normal: Technologies with relatively few inhibitors usually traverse the hype-cycle in five to eight years.

III.RELATED WORK

This section presents literature review on hype-cycle analysis for different technologies.
Wireless wide-area technologies are making the fastest approach to the plateau of productivity because of major investments and broad market appeal. Although much of the hype has passed, technology maturity still ranges widely from two to 10 years [2].
Authors [3] concluded that many XML standards will mature through year 2008 but some versions of XML will receive no further development.

Paper [8] analysed hype-cycle of DVD technology. Data are taken from the three different databases (News Articles) 1) All English Language News 2) New York Times and 3) Electronics Engineering Times. For the first case, data not followed hype-cycle but other two cases follows hype cycle but peak timing is different in both the cases. In New York Times the peak occurs in year 2003 and in Electronic Engineering Times in year 1997. If all the datasets are combined hype-cycle is not created, but if it separate out result is different.
Paper [9] analyzed MP3, Bluetooth and Blu-ray technologies. Data are taken from the two different databases All English Language News from 1) LexisNexis, 2) Compendex database. The shapes of the

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LexisNexis graphs in the first two cases, MP3 and Bluetooth, follow very well the shape of the hype-cycle. Only the third case, Blu-ray does not follow the shape depicted in the beginning. Instead, it shows an S-shaped curve with signs of abating growth. Peak of three technologies are different in different year MP3 (2000), Bluetooth (2001) and Blue-ray (2002).

Paper [1] measures the hype-cycle of hybrid automobiles with user perspective empirically. Data took by the four different resources 1) search traffic 2) oil prices 3) GDP growth rate and 4) market share. This paper conclude that hype-cycle is not for only IT industry but also traditional industries and possible the measure of expectation of consumer with search traffic.

Objective of paper [10] to analyze the PND industry follow the Gartner hype-cycle or fails. They observe 11 technologies under the PND industry with phases of hype-cycle. This research shows that the PND industry can be associated with a long fuse technology and has arrived at the slope of enlightenment within 15 years so there should be a plateau of productivity around 2020.

Paper [11] compares qualitative as well as quantitative approach of hype pattern for analysis of Voice over internet protocol (VoIP), Gene therapy and High temperature superconductivity. Data sources used are the mass media and the scientific media.

Paper [12] investigates hype-cycle of internet technology. Data sources are the publications in financial Times, Business week, the wall street journal and Harvard business review from 1992-2002 as well as NASDAQ stock index, venture capital spending in the USA, e-commerce turnover in US retail sector and internet penetration in USA.

Authors [13] reported that Agile method, Extreme Programming, has followed quite closely the Gartner hype-cycle and it has now reached the trough of disillusionment. Paper [14] analyzed ABC (Activity Based Costing) with the 20 years history. The ABC hype-cycle having the six phases which is (1) technology trigger (1984-1987), (2) peak of inflated expectations (1987-1991), (3) trough of disillusionment(1991-1995), (4) slope of enlightenment(1995-2000), (5) the plateau of productivity (2000-2006), and (6) the post-plateau phase (2006-2010). Four generation of ABC mentioned in this paper. Complete hype cycle is followed ABC.

Author [1] reported that existing research literature fails to provide sufficient consideration of its theoretical frame or its empirical verification. Authors reported that majority literature on technology hype-cycle is investigated without considering technology life cycle. It makes the interpretation of the bubble phase and the disillusionment phase difficult. More effective interpretations will become possible when a comparison is made of the hype cycle indices in conjunction with the conventional technology life cycle [1]. Theory of hype patterns that can explain the different shapes of hype-cycles in different contexts is missing [11].

IV. CLOUD COMPUTING ANALYSIS USING HYPE-CYCLE AND LIFE CYCLE

Cloud computing offers its benefits through three types of Cloud computing offers its benefits through three types of service or delivery models namely infrastructure-as-a-service (IaaS), platform-as-a-service (PaaS) and software-as-a-service (SaaS). It delivers its service through four deployment models namely, public cloud, private cloud, community cloud and hybrid cloud. Cloud computing is result of evolutionary development of several different technologies and has characteristics of many preceding operating models and technologies [15], [16]. In this paper we have considered only four sub-technologies of cloud computing namely virtualization, grid computing, service oriented architecture and web 2.0.

Methodology

1. Select suitable indicator for hype-cycle and life cycle
2. Prepare data set for hype-cycle and life cycle
3. Find the hype-cycle curve of selected technologies
4. Compare the hype cycle patterns with Gartner hype-cycle
5. Find the correlation between the hype-cycle and life cycle

To find the hype-cycle and life cycle of cloud computing technologies we have used mass media and scientific media as indicators. Under the mass media we have taken number of news articles and the under scientific media number of patents and papers. News articles have taken from the Google trend (news headlines). The dataset of patents collected at US patent office and Espacent Patent site. Paper data is collected from the IEEE explore and the Science Direct site. To search count of news articles, papers and patent following keywords are used in the title field, ‘cloud computing’, ‘virtualization’, ‘grid computing’, ‘web 2.0’, ‘service oriented architecture’, ‘platform as a service’, ‘infrastructure as a service’, ‘software as a service’, ‘public cloud computing’, ‘private cloud computing’, ‘hybrid cloud computing’.

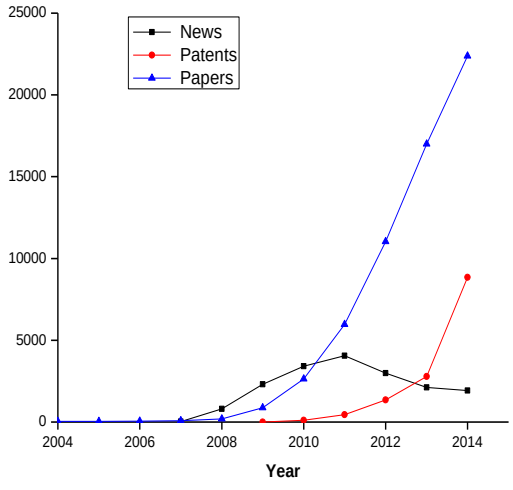

Fig.3. Cloud computing

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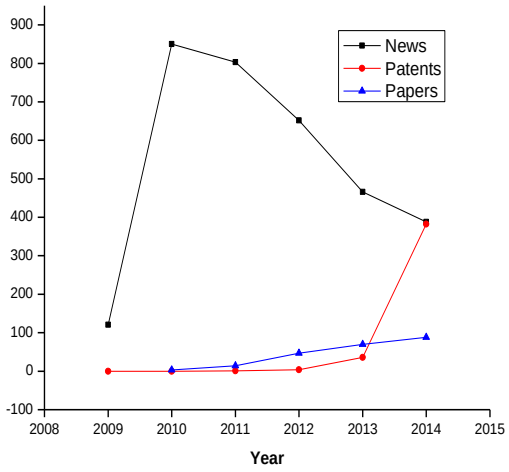

Fig. 4. Private cloud computing

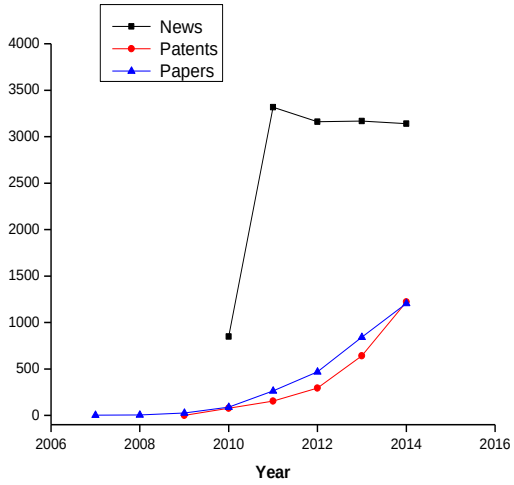

Fig.7. Infrastructure as a service

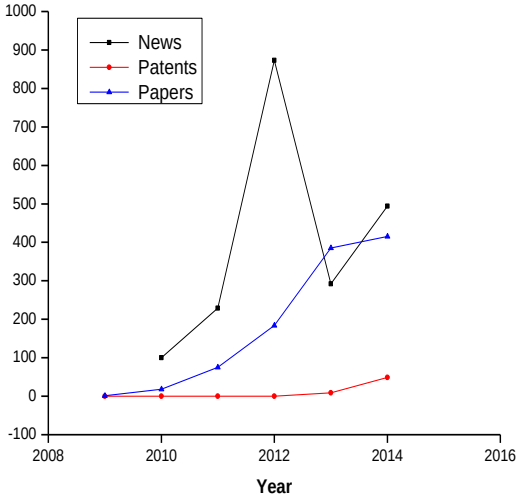

Fig.5. Public cloud computing

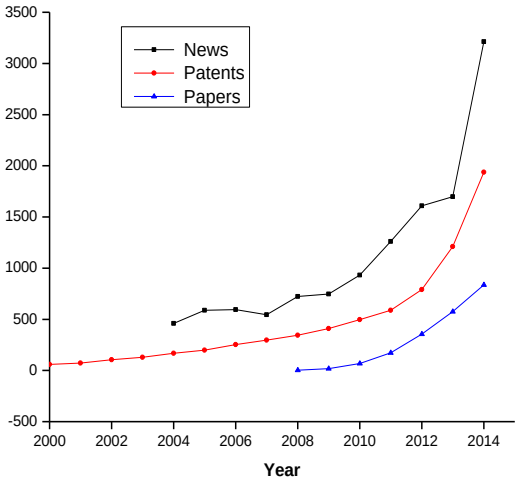

Fig.8. Platform as a service

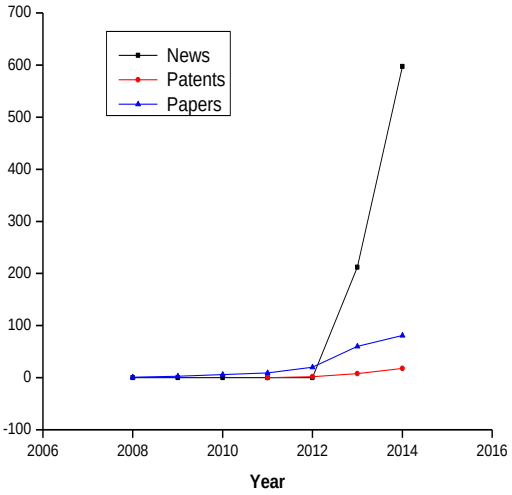

Fig.6. Hybrid cloud computing

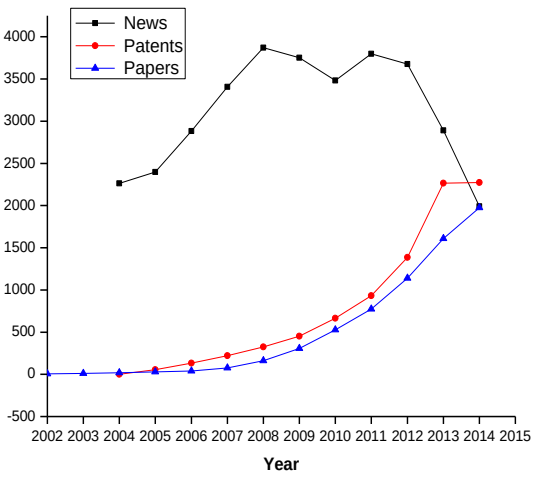

Fig.9. Software as a service

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For cloud computing, news article, papers and patents data is available from year 2007, 2009 and 1996 respectively. In year 2007 cloud computing was at the bottom of the trigger phase. In next four years it shows rapid movement and reached peak of inflated expectations in year 2011. In year 2013 cloud computing is reached bottom of disillusionment phase and in year 2014 entered into slope of enlightenment phase. The graph (figure 3) shows that cloud computing follows hype-cycle pattern. Upto year 2008 the growth in number of papers published is slow. After year 2009 the growth is exponential. Results shows that cloud computing entered in the growth phase of life cycle before reaching the peak of inflected expectation in hype-cycle. The growth in patent number is slower than papers. Cloud computing life cycle using patent indicator and hype cycle shows similar behaviour shown in figure 2. Figure 4 to 9 shows the hype cycle for cloud computing deployment models and service models.

Cloud computing deployment models

In year 2009 and 2010, private cloud computing was in the downside of trigger phase and peak of inflected expectation respectively. Next four years (2011 to 2014) it is in trough of disillusionment phase moving downwards. Public cloud computing shows rapid movement in the year 2012 and 2013. In year 2012 and 2013 it was on the peak of inflected expectation and bottom of negative hype. In year 2014 it entered in slope of enlightenment phase. In year 2012, 2013 and 2014 hybrid cloud computing is moving very fast towards the peak of inflected expectation.

The hype-cycle curve and rate of movement in the hype cycle is different for private, public and hybrid cloud computing. Private and public cloud computing has gone through the peak of inflected expectation where hybrid cloud computing is moving towards peak.

Paper publications in public cloud computing are more than private and hybrid cloud computing. Whereas number of patents in private cloud computing are more than public and hybrid cloud computing.

The life cycle pattern of cloud computing deployment models is different for papers and patents indictor.

Cloud computing service models

In year 2011, Infrastructure as a Service (IaaS) reached the peak of inflected expectation and from year 2012 to 2014 it is close to the peak on slightly down on negative hype. From year 2004 to 2014, Platform as a Service is in first phase of hype-cycle. Expect year 2014 the movement is very slow. Upto year 2007, Software as a Service is in the trigger phase. From year 2008 to 2012, it is in the peak of inflected expectation phase. But the behaviour of SaaS in second phase is different from other technologies. It shows some up and down trend. In year 2013 and 2014 it is moving rapidly of the negative hype.

The hype cycle curve and rate of movement in the hype cycle is different for three service models.

Life cycle of cloud computing service models with paper and patent indicator are slowing moving towards growth phase.

Cloud computing sub-technologies

Figure 10 to 13 shows the hype cycle for selected cloud computing sub-technologies namely virtualization, web 2.0, service oriented architecture and grid computing.

In year 2004 virtualization was at the bottom of the trigger phase. In next five years it reached to the peak of inflated expectations. From year 2010 to 2014 it shows decline towards the bottom of disillusionment phase. In year 2005 web 2.0 was at the bottom of the trigger phase. In next two years it rapidly moves towards the peak of inflated expectations. From 2008 to 2014 it shows linear decline towards the disillusionment phase. Complete data of news articles for service oriented architecture and grid computing is not available. So the hype-cycle is not clearly visible. In year 2013 SOA reached to the end of third phase and in year 2014 entered into fourth phase of hype-cycle. After year 2009, grid computing failed to get media attention.

Life cycle of selected cloud computing sub-technologies using paper indicator is in growth phase of life cycle.

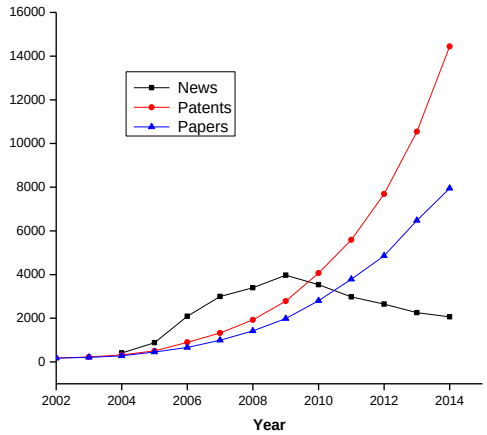

Fig. 10. Virtualization

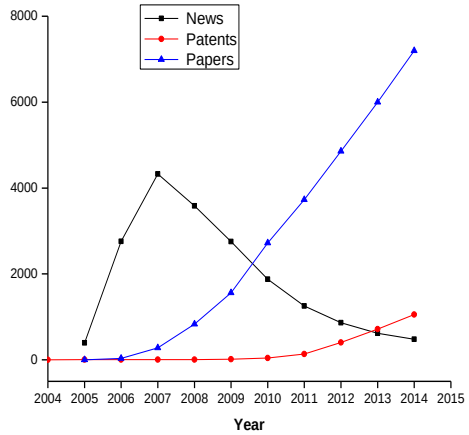

Fig. 11. Web 2.0

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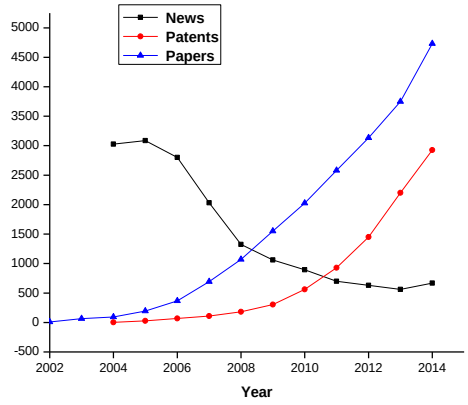

Fig. 12. Service oriented architecture

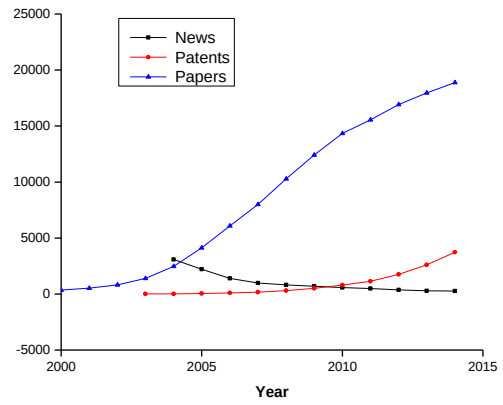

Fig. 13. Grid computing

V. GARTNER HYPE-CYCLE FOR CLOUD COMPUTING TECHNOLOGIES

This section presents the analysis of cloud computing technologies with the help of Gartner hype-cycles available on Gartner website [17]. The limitation of the investigation is that analysis is not complete because it uses only freely available hype-cycle reports published by Gartner. The hype-cycle graphs presented in this section are not on scale.

Figure 14 shows the progress of cloud computing in Gartner hype-cycle. Cloud computing technology appeared at the high end of the trigger phase in the year 2008. In year 2009 it reached to the top of the peak of inflated expectations. In year 2010 and 2011 cloud computing was close to the peak but slightly down on the negative hype. The movement of cloud computing in the year 2010 and 2011 was very steady. Year 2012 and 2013 shows fast downward movement along the hype-cycle curve. In year 2014 it reached close to the end of negative hype.

Figure 15 shows the hype cycle for cloud computing deployment models- private cloud, public cloud, community cloud and hybrid cloud.

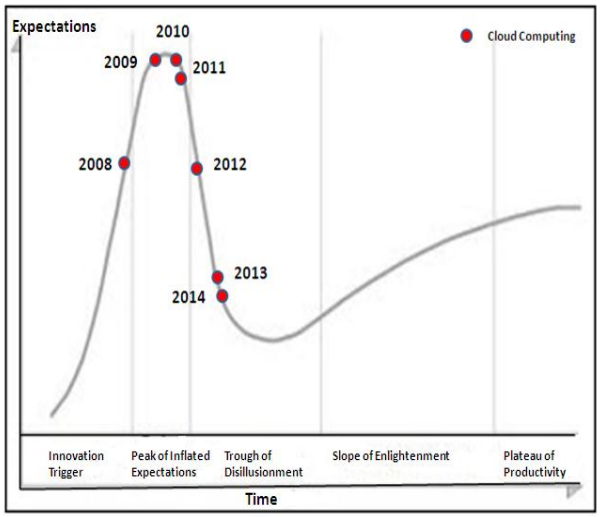

Fig.14. Hype-cycle for cloud computing

Source: (Gartner hype-cycle for cloud computing 2009, 2010, 2011, and 2012), (Gartner hype-cycle for emerging technology 2008, 2013 and 2014)

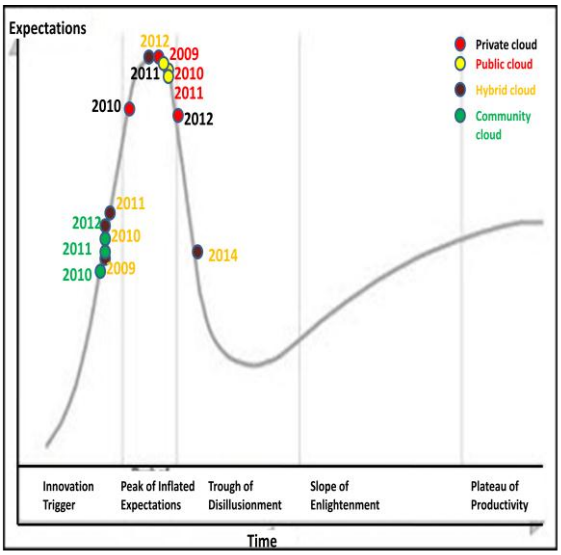

Fig.15. Hype-cycle for cloud computing deployment models

Source: (Private cloud: Gartner hype-cycle for cloud computing 2010, 2011, and 2012), (Public cloud: Gartner hype-cycle for cloud computing 2009, 2010, and 2011), (Hybrid cloud: Gartner hype-cycle for cloud computing 2009, 2010, 2011, and 2012 Gartner hype-cycle for emerging technology 2014), (Community cloud: Gartner hype-cycle for cloud computing 2010, 2011, and 2012)

Private cloud was on the peak of inflected expectations in the year 2011. In year 2010 and 2012 it was close to peak on positive hype and negative hype respectively. In the year 2009, 2010 and 2011, public cloud was in the peak of inflected expectations slightly down on the negative hype. From year 2010 to 2012, community cloud computing is on down side of technology trigger phase. The movement towards the peak is very slow. Year 2009 to 2011, hybrid cloud computing is on down side of technology trigger phase. The movement towards the peak is very slow. In year 2012 it showed fast movement and reached the peak

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of inflected expectations. In year 2014 it was on downside of negative hype.

Figure 16 shows the hype-cycle for cloud computing service models- Infrastructure as a service (IaaS), Platform as a Service (PaaS) and Software as a Service (SaaS).

Platform as a Service (PaaS) is on the top of the peak of inflated expectations in the year 2010 and 2011. In year 2012 PaaS was close to the peak but slightly down on the negative hype. In year 2011 Private PaaS was on the down side of technology trigger phase. In year 2012 is shows fast progress towards the second phase of hype cycle. In year 2011 Infrastructure as a service was in the second phase of hype cycle. Close to the peak but slightly down on the negative hype. Year 2012 shows rapid progress of IaaS from the third phase of hype-cycle. It is close to the end of trough of disillusionment phase. In year 2009 SaaS was close to the end of trough of disillusionment phase. From year 2010 to 2012, it is in the slope of enlightenment phase.

Figure 16 shows that the position and movement of the cloud computing service models IaaS, PaaS and SaaS on the hype-cycle are different.

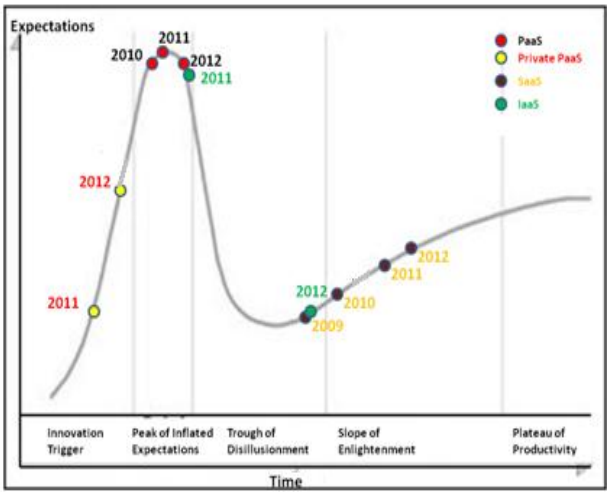
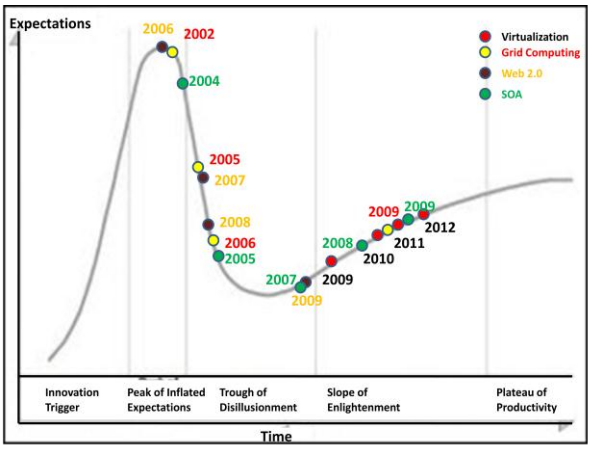


Fig.16. Hype-cycle for cloud computing service models Source: (PaaS: Gartner hype-cycle for cloud computing 2010, 2011, and 2012), (Private PaaS: Gartner hype-cycle for cloud computing 2011, and 2012), (SaaS: Gartner hype-cycle for cloud computing 2009, 2010, 2011, and 2012), (IaaS: Gartner hype-cycle for cloud computing 2011, and 2012).

Figure 17 shows the hype cycle for cloud computing sub-technologies such as the virtualization, grid computing, web 2.0 and service oriented architecture (SOA).

Fig.17. Hype-cycle for cloud computing service models Source: (Virtualization: Gartner hype-cycle for cloud computing 2009, 2010, 2011, and 2012), (Grid computing: Gartner hype-cycle for emerging technology 2002, 2005, 2006, Gartner hype-cycle for cloud computing 2009), (Web 2.0: Gartner hype-cycle for emerging technology 2006, 2007, 2008, 2009), (SOA: Gartner hype-cycle for emerging technology 2004, 2005, 2007, 2008, and 2009)



From year 2009 to 2012, virtualization was in the slope of enlightenment phase. Grid computing was on the peak of inflected expectations and in slope of enlightenment phase in the year 2002 and 2009 respectively. Web 2.0 was at the peak level in the year 2006 and from 2007 to 2009 in the disillusionment phase moving towards slope of enlightenment phase. In year 2004, SOA was in the peak of inflected expectations slightly down on the negative hype. From year 2005 to 2006 in the phase of trough of disillusionment and from 2008 to 2009 in the slope of enlightenment phase.

VI. CONCLUSION

Hype-cycle is one of the popular methods for investigating technology change. In recent years cloud computing has received attention by researchers and industry, so cloud computing technologies are investigated for empirical validation of hype-cycle. In this investigation news articles are used as an indicator for hype-cycle. It is observed that news articles can effectively capture the first three phase of hype cycle.

The results shows that cloud computing, virtualization and web 2.0 follow similar hype-cycle pattern described by J. Fenn [7]. Investigation shows that the hype-cycle curve and rate of movement in the hype cycle is different for different cloud computing deployment models, service models and sub-technologies. The hype-cycles obtained using news articles from Google trend differs from Gartner hype-cycle with respect to position in hype cycle and rate of movement of the technology in the hype cycle. For majority of the cloud related technologies papers data is available before the news articles. Result shows that all the selected cloud computing sub-technologies are passed through negative hype. Author [18] reported that cloud computing is combination of existing mature technologies. Presented results on hype-cycle of cloud computing sub-technology validate the statement.

This paper also investigates the relationship between hype and life cycle. Number of research papers published and patents filed are used as indicators to find the life cycle. For majority of the cloud computing technologies the life cycle curve overtakes hype-cycle when technology is in negative hype.

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