Trend and Sale of Computer & Communication Patents in the United States

Pratheeba Vimalnath and Anjula Gurtoo

Abstract—**The paper presents the growth of Computer & Communication (C&C) technologies in the past decade, 2005 –2014, using patent data in the matured United States (US) market and investigates the association between growth and the sale of patents in different C&C patent classes. The results demonstrate a striking 978.29% and 487.65% growth in information security (US class 726) and financial data processing (class 705) areas over the past decade, both belonging to the computer hardware and software category. Mapping of trend with sold US patents during 2006-2008, does not show more sales in the growing patent classes and not all classes sold more demonstrate higher growth. The pulse or digital communication space (class 375) for instance is the highest sold patent class but has relatively lesser growth in the past decade. The information storage component represented by class G9B, show lesser growth as well as lesser sale, indicating the death phase of the technology component. The implications and reasons for the results observed are discussed.**

Index Terms—**Computer & Communication, patent class, patent sale, technology growth.**

I. INTRODUCTION

The Computer & Communication (C&C) field has grown tremendously in the past decades with its applications ranging from day-to-day mobile communication between individuals to satellite communication across planets. The rapid evolution of C&C technologies is evident in the transition from using land line phones to smart phones [1]; from floppy disc to thumb drives to cloud computing services [2], [3]. The rapid evolution of C&C technologies indicates their shorter life cycles as well, compared to say, medical technologies or pharmaceutical inventions where the life cycle is relatively longer [4]. Market players in the C&C technology space therefore compete aggressively to increase their market share and profit within a shorter time period.

The paper explores patenting in the C&C technology field in the mature market of United States and provides insights on the association between growth of C&C technology field patents and their sale in auctions. The paper specifically focuses on the following: (1) provides an overview of C&C technological growth during the last decade (2005 to 2014) specifically in the four categories of C&C technology space namely computer hardware & software, computer peripherals, information storage and communications (2) verifies whether the growing C&C technology areas are also the ones transacted in patent market.

The paper aims to understand the growth of C&C technology field in US over the decade 2004-2015. The percentage increase in patenting from the beginning to the end of the study period is calculated to identify the fast-growing C&C technology areas. The year on year patenting in each of the C&C technology patent classes is used to understand their growth cycle. The growth pattern is then mapped with the sold US C&C patents to understand whether all the C&C components showing higher growth in patenting are also the ones sold more or vice versa.

II. LITERATURE REVIEW AND RESEARCH GAPS

A. C&C Technology in the United States

Though the growth contribution of C&C technologies to the economy has been high in recent times, literature on the evolution of C&C technology field post 2000 is limited. The US C&C inventions post 2000 majorly was within the entertainment and communication devices category [5]. The world however has moved beyond entertainment and communication devices towards virtual, cashless and e-services post 2000 [6].

Whilst many countries have played critical role in the evolution of C&C technology, US consistently stands ahead in developing and deploying novel C&C technologies and applications [7]. Particularly, during the initial stages of internet technology evolution, the US federal R&D funding, venture capital financing, strong collaboration amongst university, defense, and industry researchers, large US domestic market, strong US computer hardware and software industry and the patenting tradition in US has played a crucial role in surpassing the efforts by other countries like Europe, and Japan [7]-[9].

The US which surpassed the then dominant UK in output per capita during the mid 20th century however started slowing down after 2000 [5]. The C&C technology revived the US economy only for a short period (~1996 to 2004) [5].

The C&C technology growth post 2004 has limited evidence compared to the pre 2004 period. The paper aims to present an overview of the decade post 2004, of the growth of different technology components constituting the C&C technology field using US patent data.

B. Patent as a Tool for Understanding Technology Growth

Patents are major outcomes of R&D efforts. Studies have used patent data for monitoring the growth of technologies like information and communication technology [10], fuel cell, food safety and optical storage [11], stem cell [12], solar

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cells [13] and many more. The knowledge about patenting indicates technology growth trends as patent indicates future investment decisions [14], conveys the R&D strength of an organization to the capital market [15,16], explains technology innovation capability of a country [17] and provides competitive intelligence [18]. While we acknowledge using patent data has limitations as not all inventions are patented because of reasons like alternative protective mechanisms (trade secrets), high patenting cost or lack of the invention meeting the patentability criteria, the usefulness of patents for technology monitoring cannot be ignored [10].

C. C&C Technology Growth and C&C Patent Sale

The C&C technology specificity of patents and patent value is evidenced in literature. Hall, Jaffe, and Trajtenberg [19] have studied U.S. patents during 1963-1999 across six technology areas namely Computers and Communications, Drugs and Medical, Electrical and Electronics, Chemical, Mechanical and Others. The authors compared patent related variables namely lag, number of claims and number of citations across technology fields and found a significant difference. For example, the average claims for C&C field is 16.8 and that of others is 13.7.

Lanjouw [20] demonstrate a 52% probability of a patent remaining valuable at age ten in the computers technology field but only a 32% probability in combustion engines technology. Serrano [21] reported that 47.3% of patents were active till expiry in C&C field and 67.9% in other fields combined. Patents from the C&C field fetched higher price compared to patents from other technology fields [22].

Hence, literature demonstrates the difference in nature and value of C&C patents from that of the other field patents. Despite shorter life cycles of C&C innovations, 47.3% of C&C patents were actively maintained till expiry (~20 years) [21]. The transaction of the actively maintained C&C patents and their mapping with their rate of patenting growth however remains scarcely addressed. The paper maps the growth patterns of actively maintained patents under different C&C patent classes with their sales patterns in auctions to verify whether the high growth C&C patent classes also are sold more and vice versa.

III. DATA AND METHODOLOGY

A. Data

Two sets of data are used for the paper. The first set includes all the C&C technology field patents granted in US. The US C&C patents are retrieved for two time periods – all C&C US patents granted until December 2004 and until December 2014 – to understand the C&C technological evolutions during the decade, 2005 to 2014. The patent data is collected from the United States Patents and Trademark Office (USPTO), the official patent database of US patents. A patent is considered as a C&C patent if it has one or more of US C&C patent classes, in Table I, mentioned in the front page of the patent document. The number of US C&C patents is also obtained year on year between 2005 and 2014 in order to plot the growth trend of each of the C&C patent classes.

The second dataset includes a set of C&C US patents auctioned by an US auction firm OceanTomo during April 2006-October 2008. The auction sample period falls within the first five years of the decade 2005-2014 studied for C&C evolution. Patents sold in other time periods are not included due to the unavailability of the relevant data which are often kept confidential. Amongst the patents sold in the auctions, a total of 456 US patents are identified as C&C patents as they included one or more of C&C technology patent classes.

TABLE I: C&C TECHNOLOGY FIELD RELATED US PATENT CLASSES AND THEIR DEFINITIONS

Computer Hardware & Software	
USPC 341	Coded data generation or conversion
USPC 380	Cryptography
USPC 382	Image analysis
USPC 700	Data processing: generic control systems or specific applications
USPC 701	Data processing: vehicles
USPC 702	Data processing: measuring
USPC 703#	Data processing: structural design
USPC 704	Data processing: speech signal processing
USPC 705	Data processing: financial
USPC 706	Data processing: artificial intelligence
USPC 707	Data processing: database and file management or data structures
USPC 708	Electrical computers: arithmetic processing and calculating
USPC 709	Electrical computers and digital processing systems: multicomputer data transferring
USPC 710	Electrical computers and digital data processing systems: input/output
USPC 712	Electrical computers and digital processing systems: processing architectures and instruction processing
USPC 713	Electrical computers and digital processing systems: support
USPC 714	Error detection/correction and fault detection/recovery
USPC 715#	Data processing: presentation processing of document
USPC 716#	Computer-aided design and analysis of circuits and semiconductor masks
USPC 717#	Data processing: software development
USPC 718#	Electrical computers and digital processing systems: virtual machine task or process management or task management/control
USPC 719#	Electrical computers and digital processing systems: interprogram communication or interprocess communication (ipc)
USPC 725#	Interactive video distribution systems
USPC 726#	Information security
Communications	
USPC 178	Telegraphy
USPC 333	Wave transmission lines and networks
USPC 340	Communications: electrical
USPC 342	Communications: directive radio wave systems and devices (e.g., radar, radio navigation)
USPC 343	Communications: radio wave antennas
USPC 358	Facsimile and static presentation processing
USPC 367	Communications, electrical: acoustic wave systems and devices
USPC 370	Multiplex communications
USPC 375	Pulse or digital communications

USPC 379	Telephonic communications
USPC 385	Optical waveguides
USPC 455	Telecommunications
Computer Peripherals	
USPC 345	Computer graphics processing and selective visual display systems
USPC 347	Incremental printing of symbolic information
Information Storage	
USPC 360	Dynamic magnetic information storage or retrieval
USPC 365	Static information storage and retrieval
USPC 369	Dynamic information storage or retrieval
USPC 711	Electrical computers and digital processing systems: memory
USPC 720#	Dynamic optical information storage or retrieval
USPC G9B#	Information storage based on relative movement between record carrier and transducer

B. C&C US Patent Classes

Inventions at the time of patenting are classified under different patent classes based on the technology area and the specific functionalities of the patented invention. The US patent classification system has a dedicated set of patent classes covering different aspects of C&C inventions. Hall, Jaffe, and Trajtenberg [19] have broadly classified the C&C related US patent classes under four categories namely, communications, computer hardware and software, computer peripherals and information storage.

The C&C patent classes not included in the classification system by [19] but protecting one or more aspects of C&C related areas are also included for the paper. A total of 44 US patent classes relating to C&C field are identified. Table I gives the US patent classes within each of the categories and their definitions. The newly included classes are indicated by #. The analysis is restricted to the level of main classes and not at the sub class level in order to obtain a broader understanding of the C&C technological growth.

The USPTO stopped using the US patent classification (USPC) with effect from April 2015 and started using the Cooperative Patent Classification (CPC). Since the data falls within the period before the change over, the USPC is used for the paper.

C. Method of Analysis

The method used for the paper includes three steps. First, US patenting in the set of US patent classes protecting C&C related inventions are studied for two time periods - all C&C US patents as of December 2004 and December 2014. The percentage change in the number of patents within each patent class is calculated for identifying the high growth C&C technology component. The Chi-square test is used to verify whether the C&C technology categories and the specific patent classes vary significantly in their growth over the past decade. The second analysis gives a detailed year on year growth trend of the C&C technology classes, thereby demonstrating the technology growth cycle curves. Third, a set of C&C patents sold in auctions during 2006-2008 are analyzed for their C&C patent class distributions and verified whether the sale pattern of the sold C&C patents matches with the overall C&C patenting trend.

IV. RESULTS

A. A Decade Long Patenting Trend in C&C Technology Field

Table II gives the distribution of the total number of US patents within the four C&C technology categories namely communications, computer hardware & software, computer peripherals and information storage for two time periods – as of December 2004 and as of December 2014.

Amongst the four C&C categories, maximum number of patents is observed in computer hardware & software category followed by communications, information storage and computer peripherals in both the time periods. More than 200% increase in patenting is evidenced in computer hardware and software category. Communications and computer peripheral categories show more than 100% increase in patenting.

TABLE II: DISTRIBUTION AND GROWTH OF US C&C PATENTS AS OF DECEMBER 2004 AND DECEMBER 2014

| C&C technology field categories	Total number of US grants			% increase
	as of Dec 2004	Jan 2005 - Dec 2014	as of Dec 2014	
Communications	262445	357517	619962	136.23%
Computer Hardware & Software	269787	561180	830967	208.01%
Computer Peripherals	55682	76960	132642	138.21%
Information Storage	162411	107418	269829	66.14%
Chi-square test	Chi-square=26536.99. df=3, p-value=0.000***			

*** $p < 0.01$
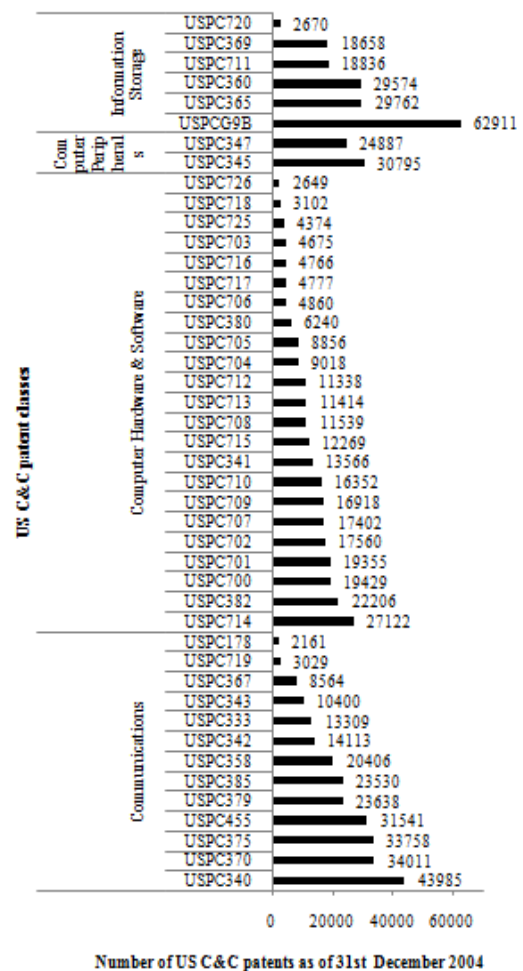
Fig. 1. Distribution of US patents across C&C patent classes as of 31st December 2004.

The information storage category shows the least growth of only 66% in the past decade. The volume of patents in computer peripheral components though lesser in number than all the other three categories in both the time periods, shows higher growth percentage than information storage category. Chi-square test comparing the volume of US patents within the four categories across two time periods show statistically significant difference in growth of C&C patents across the four categories.

Fig. 1 and 2 give the distribution of the number of US patents granted within the specific C&C US patent classes until the end of December 2004 and end of December 2014 respectively, as obtained from the official USPTO database.
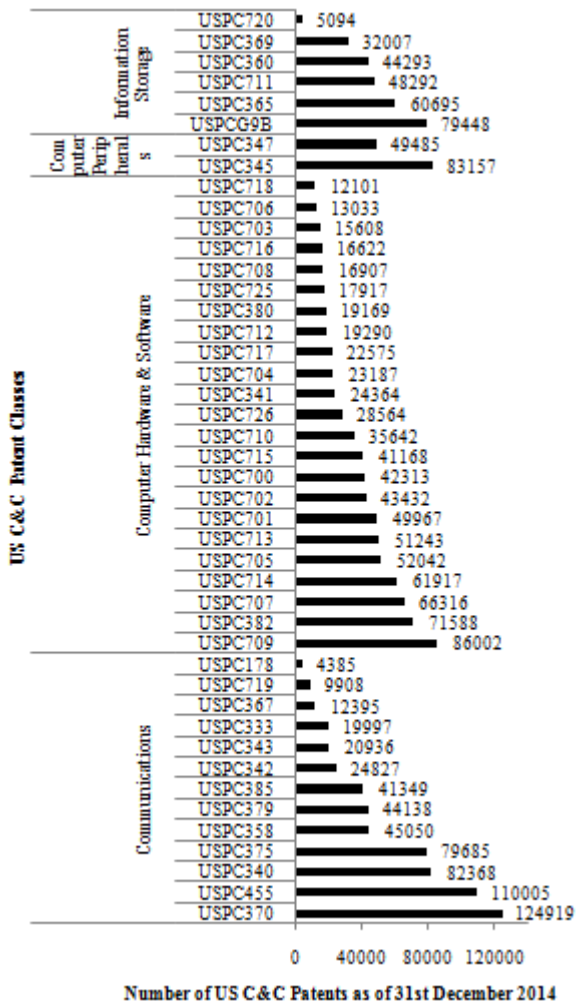

Fig. 2. Distribution of US patents across C&C patent classes as of 31st December 2014.

Fig. 1 shows as of December 2004, the class G9B – 'Information storage based on relative movement between record carrier and transducer', has maximum patents (62,911 patents) followed by class 340 – 'Communications: electrical', with 43,985 patents and class 370 – 'Multiplex communications', with 34,011 patents. In contrast, as seen in Fig. 2, a decade later Multiplex communications (class 370) became the highly patented class (124,919 patents) followed by class 455 - Telecommunications (110,005 patents) and class 709 - Electrical computers and digital processing systems: multicomputer data transferring (86,002 patents). Whilst observation of patent volumes indicate the dominance

of Multiplex and Telecommunications patents, the growth percentage projects a different set of C&C areas as growing. Fig. 3 gives the longitudinal growth trend of the patent classes under the four categories.

TABLE III: PERCENTAGE INCREASE IN US PATENTING IN C&C TECHNOLOGY CLASSES OVER THE PAST DECADE

US Patent Class	% increase in the last decade	US Patent Class	% increase in the last decade
Computer Hardware & Software		*Communications*	
USPC726	978.29%	USPC370	267.29%
USPC705	487.65%	USPC455	248.77%
USPC709	408.35%	USPC719	227.10%
USPC717	372.58%	USPC375	136.05%
USPC713	348.95%	USPC358	120.77%
USPC725	309.63%	USPC178	102.92%
USPC718	290.10%	USPC343	101.31%
USPC707	281.08%	USPC340	87.26%
USPC716	248.76%	USPC379	86.72%
USPC715	235.54%	USPC342	75.92%
USPC703	233.86%	USPC385	75.73%
USPC382	222.38%	USPC333	50.25%
USPC380	207.20%	USPC367	44.73%
USPC706	168.17%	$\chi^2=17007.87, df=12, p =0.000$	
USPC701	158.16%	*Information storage*	
USPC704	157.12%	USPC711	156.38%
USPC702	147.33%	USPC365	103.93%
USPC714	128.29%	USPC720	90.79%
USPC710	117.97%	USPC369	71.55%
USPC700	117.78%	USPC360	49.77%
USPC341	79.60%	USPCG9B	26.29%
USPC712	70.14%	$\chi^2=6327.06, df=5, p =0.000$	
USPC708	46.52%	*Computer Peripherals*	
$\chi^2=29683.05, df=22, p=0.000$		USPC345	170.03%
		USPC347	98.84%
		$\chi^2=895.44, df=1, p =0.000$	

***p<0.01

Table III gives the percentage growth in each of the 44 US C&C patent classes over the last decade. Two of the patent classes from the computer hardware & software category, namely, Informational security (class 726) and financial data processing (class 705) show strikingly highest growth of 978.29% and 487.65% respectively.

Amongst the communication related classes, multiplex communications and telecommunications stands tall with growth of 267.29% and 248.77%, respectively. On the other hand, the class G9B in the information storage category, dominant a decade ago, appears to have lost the game with only 26.29% increase in patenting. Instead, the class 711 emerges with highest growth (156.38%) in the information storage category.

The chi-square results in Table III show significant difference in the patent volumes across four categories in the time period studied indicating certain components significantly growing than the others.

Evidently, almost all patent classes have grown over the past decade but with varying growth rates (Fig. 3). Multiplex communications (USPC 370), telecommunications (USPC 455), and multi-computer data transferring (USPC 709) show rapid growth over the past decade. A sudden death of the class G9B is evidenced from 2008 to 2009. Interestingly, none of the other information storage related inventions show sudden growth between 2008 and 2009. Rather, the class 711 related to electrical computers and digital processing systems memory and class 365 related to static information storage

and retrieval, show a steady growth over the past decade surpassing the G9B class and lead the information storage space.
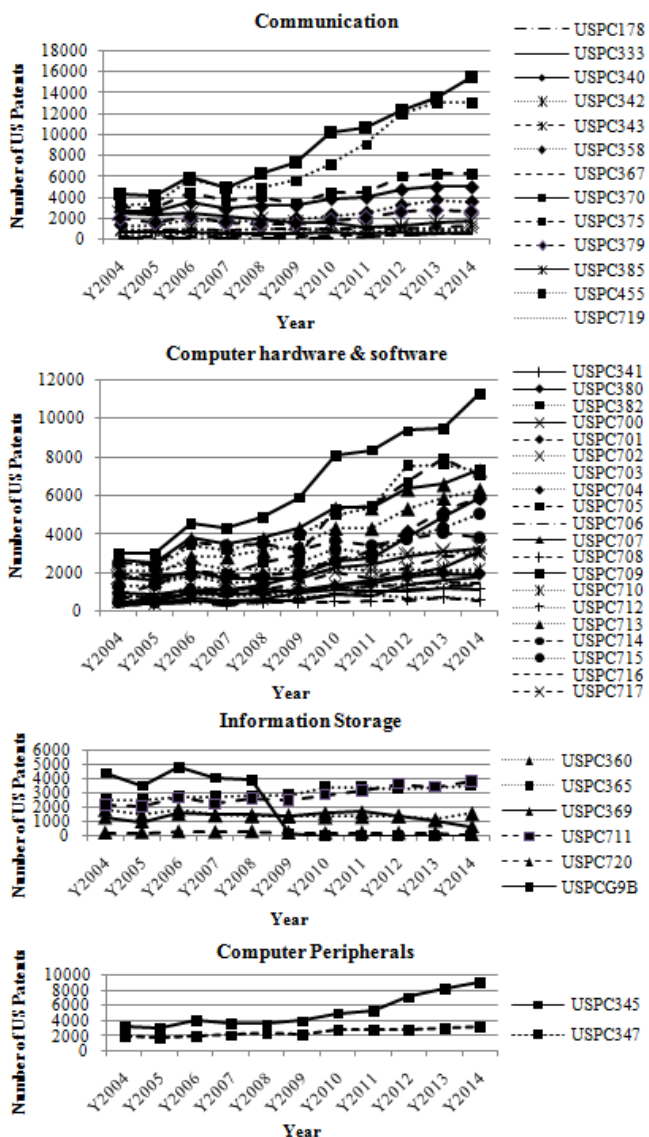

Fig. 3. Growth trend of US patent classes in the four categories of the C&C technology field.

B. C&C Patent Class Distribution of US C&C Patents Sold in OceanTomo Auctions during 2006-2008

Fig. 4 gives the distribution of the auctioned US C&C patents across the C&C patent classes. Out of the 456 US C&C patents auctioned, majority (96.7%) of the patents had one or more computer hardware & software components, followed by patents with communication (55.5%), information storage (16.2%) and computer peripherals (7.5%) related components.

Comparison of Fig. 4 with Fig. 1, Fig. 2 and Table III, highlights class 345 in computer peripherals category as having higher patent volume and higher growth is also the one transacted more. In the information storage category, the highest growth class 711 is transacted more than the high volume class, G9G. Within the computer hardware & software category, the top two highest transacted patent classes are the ones with second and third highest growth rates.

The class 726 – information security related inventions shows the highest growth of 978.29% but is not transacted more. Similar is the case with the other computer software & hardware patents that show higher growth but not transacted more.

On the other hand, in communications category, the patent class 375 (pulse or digital communication) with highest sold patents does not show highest growth in the past decade. Assuming successful patent transactions indicate a need for inventions protected by the patent and lesser growth rate indicates relatively lesser R&D in that space, the results show a need for research in the pulse or digital communication (class 375), which ranks four in the volume of patenting within the communication category. The second highest transacted communication patent class 455 shows second highest growth within the communication category.
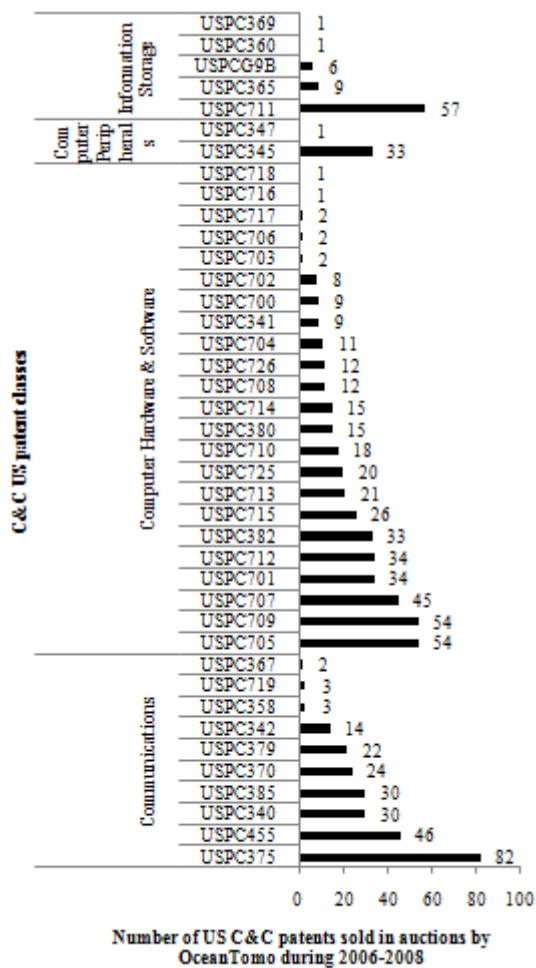

Fig. 4. Distribution of US C&C patents auctioned during April 2006 – October 2008.

Like in the case of computer hardware & software category, class 370 which shows highest growth within the communication category show relatively lesser transactions than the classes 375, 455, 340 and 385.

V. DISCUSSION AND CONCLUSION

The paper explores the growth of Computer & Communication (C&C) technologies over the past decade

using patented C&C inventions in United States.

Amongst the four categories studied, computer software & hardware and communication related inventions are patented more than information storage and computer peripheral inventions indicating higher R&D in that space. Within the four categories, the specific C&C components also show growth variations in the past decade. Information security (USPC 726), multiplex communications (USPC 370), electrical computers and digital processing systems memory (USPC 711) and computer graphics processing and selective visual display systems (USPC 345) show dominant growth within the categories computer hardware & software, communications, information storage and computer peripherals respectively. Post 2000 though was reported to be majorly focusing on entertainment and communication devices [5], the results show growing focus towards hardware & software aspects like information security, financial data services as well as information storage.

The mapping between the growth trend of C&C patent classes and their sale pattern leads to three key findings. First, not all C&C classes with high volume sales are high growth classes. The pulse or digital communication component (class 375) is the highest sold but shows lesser growth with 22 other patent classes out of the total 44 C&C US patent classes showing higher growth than the class representing pulse and digital communication. The finding reflects the market need though R&D is less in this area.

Second, not all high growth C&C components are sold more. The class 726 – information security related inventions show the highest growth but not transacted more. The possible reasons could be: (1) R&D in those areas may be carried out by the firms commercializing these inventions themselves and hence not necessarily transacted in the patent market or (2) those may be technology areas well ahead of their time and hence not transacted at the moment.

Third, the results identify the C&C patent class which was a leading technology component, but showed very less growth during the study decade as well as lesser sales, pointing towards the death of the technology component. R&D in the area of information storage based on relative movement between record carrier and transducer (class G9B), is the weakest over the past decade despite its dominance in patenting until 2004. Particularly between 2008 and 2009, a drastic decline of the patenting in G9B class is evident but no alternative technology components can be seen emerging drastically during that time. The information storage component namely the electrical computers and digital processing systems memory (class 711) however shows a steady growth over the past decade surpassing the G9B class and dominates the information storage space as of 2015. The death of the technology components may be either due to drastic shift in the technology base, like disruptive innovations displacing the existing technology innovations from the market either quickly or slowly over time as described by Christensen [23] or due to non-usage.

The findings of this study reveal the striking growth in the areas of information security, financial data processing and multicomputer data transferring. The growth in the above areas clearly indicates the evolution of C&C technologies towards secure online data communication services. The results corroborate with the increased diffusion of e-commerce and e-payment technologies which are in the forefront at present [6]. Furthermore, the findings of this study validate the usefulness of patent data for understanding the market dynamics of a technology area as well.

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