Internet of Things (IoT) Inventive Energy

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INTERNATIONAL PATENT CLASSES (IPC): Internet of Things (IoT)

IPC Domain	Description
G05B19/418	Programme-control systems -> electric -> Total factory control, i.e. centrally controlling a plurality of machines, e.g. direct or distributed numerical control (DNC), flexible manufacturing systems (FMS), integrated manufacturing systems (IMS), computer integrated manufacturing (CIM)
G08C17/02	Arrangements for transmitting signals characterised by the use of a wireless electrical link -> using a radio link
G06F15/16	Digital computers in general; Data processing equipment in general -> Combinations of two or more digital computers each having at least an arithmetic unit, a programme unit and a register, e.g. for a simultaneous processing of several programmes
H04B7/26	Radio transmission systems, i.e. using radiation field -> for communication between two or more posts -> at least one of which is mobile
H04L12/26	Monitoring arrangements; Testing arrangements
H04L12/28	Data switching networks -> characterised by path configuration, e.g. LAN (Local Area Networks) or WAN (Wide Area Networks)
H04L29/06	Communication control; Communication processing -> characterised by a protocol
H04L29/08	Communication control; Communication processing -> characterised by a protocol -> Transmission control procedure, e.g. data link level control procedure
H04W72/04	Local resource management, e.g. selection or allocation of wireless resources or wireless traffic scheduling -> Wireless resource allocation
H04W84/18	Network topologies -> Self-organising networks, e.g.ad hoc networks or sensor networks

Internet of Things (IoT) is a collection of objects with embedded sensors and electronics. There are an increasing number of internet-connected devices in a smart home environment. IoT creates a framework for communication and control. It is on the cusp of being a mainstream consumer technology.

Using sensors, internet-enabled objects such as refrigerators, furniture, lights, automotive transmissions, and clothing, collect data and *automatically* communicate with other Internet-enabled devices for processing. Collected data can be analyzed to made decisions, such as controlling the connected devices, or to adjust what is being collected.

We identified following top 10 International Patent Classification (IPC) in Internet of Things (IoT) domain through the study of key patents. The overall number of Applications published in the United States Patent and Trademark Office (USPTO) and Patents granted by USPTO are given in the table below (from the year 2010 till 2017. These are total numbers granted and published by the world at large at USPTO in that specific year.

S.No	IPC Domain	Year							
1	**B60W10/06**	2010	2011	2012	2013	2014	2015	2016	2017
	Application	29	22	22	44	103	221	211	277
	Granted	54	58	40	57	34	141	208	308
2	**B60W10/10**	2010	2011	2012	2013	2014	2015	2016	2017
	Application	50	22	39	113	277	246	256	357
	Granted	288	292	296	304	311	468	784	1247
3	**B60W10/18**	2010	2011	2012	2013	2014	2015	2016	2017
	Application	6175	5928	6336	3678	845	51	9	44
	Granted	17488	21987	27054	32109	38346	43138	47331	51233
4	**B60W10/20**	2010	2011	2012	2013	2014	2015	2016	2017
	Application	21	57	67	102	158	161	142	151
	Granted	1	1969	1981	24	19	200	345	400
5	**B62D15/02**	2010	2011	2012	2013	2014	2015	2016	2017
	Application	1150	1308	1320	967	1271	2163	2736	3091
	Granted	759	747	729	898	1336	1885	2519	3036
6	**B60R11/04**	2010	2011	2012	2013	2014	2015	2016	2017
	Application	627	424	385	278	113	290	506	638
	Granted	1	1	2055	1	1	2505	1960	1620
7	**G05D1/02**	2010	2011	2012	2013	2014	2015	2016	2017
	Application	1	341	225	2149	5386	8850	10856	11511
	Granted	1	683	1512	2161	2534	6714	10622	12337
8	**G05D1/10**	2010	2011	2012	2013	2014	2015	2016	2017
	Application	16	7	9	1109	3270	7745	9880	10442
	Granted	25	32	40	39	56	3467	7369	9709
9	**G08G1/09**	2010	2011	2012	2013	2014	2015	2016	2017
	Application	1022	1286	2317	2541	1765	3874	4659	4465
	Granted	5	28	74	130	378	1698	3004	4026
10	**G06K9/62**	2010	2011	2012	2013	2014	2015	2016	2017
	Application	9	6	61	76	105	100	63	209
	Granted	1	2	4	7	22	329	654	785

STATE OF ART OF ANY TECHNOLOGY USING CRAFITTI's INVENTIVE ENERGY

Inventive Energy (IE) is a yearly metric of the trend of last five years of invention activity in the specific technological domain such as Internet of Things (IoT) calculated based on a number of patent applications published and a number of patents granted in the respective technological domain. **Inventive energy is a composite metric of two indices – Patent Intensity Index and Patent Activity Index.**

CRAFITTI's **INVENTIVE ENERGY** measures the pace and intensity of **inventive activity** in a particular technological field. Inventive Energy provides a true picture of the state of the art of technology as it is a **composite metric** of Patents Granted and Patent Applications published in specific technology domains annually for a period of five years.

Inventive Energy *in specific technology domains can be utilized by existing technology players, start-ups, new players, investors, VCs, Research and Development teams and technology and Product Strategy Teams to design more informed future.*

Patent Intensity Index of a year is measured in terms of the yearly average of a number of total patents granted and patent applications published in last 5 years. *As an analogy, the Patent Intensity Index is denoted as the Mass which is reflected as a number of Patents and Applications granted and published respectively in the preceding 5 years.*

Patent Activity Index is measured in terms of the yearly average of *relative* pace of patent applications and granted patents in the IPC domain. *As an analogy, the Patent Activity Index denotes the Velocity or relative pace of Patents and Applications, granted and published respectively in the preceding 5 years, with higher weightage assigned to recent years.*

For any year, the two indices include a measure of yearly averages of last five years of a number of applications published and patents granted. For example, for 2017, these indices use data from years 2013-2017.

Patent Activity Index of top 10 Internet of Things (IoT) IPC classes for years 2014-2017

A value of **Patent Activity Index** *is less than 1.0 indicates that relative average number of applications filing is reducing compared to a number of patents being granted.* **The index also gives a red, amber and green signal.** Red indicates the value of the index is less than 1.0. **Amber** indicates it is between 1.0 and 2.0 and green indicates it is above 2.0, i.e., *the number of applications being published every year on an average is more than 2 times the number of patents being granted on an average*. A higher value of patent activity index is an indication of more recent inventive activity in the domain or the specific IPC class. In turn, a higher activity index will signify a higher Inventive Energy. *Activity Index is analogous to*

the velocity of the particle. The PAI (Patent Activity Index) of top 10 Internet of Things (IoT) IPCs for years 2014-2017 are given below.

IPC Domain	Description	BM-PAI 2014	BM-PAI 2015	BM-PAI 2016	BM-PAI 2017
G05B19/418	Programme-control systems -> electric -> Total factory control, i.e. centrally controlling a plurality of machines, e.g. direct or distributed numerical control (DNC), flexible manufacturing systems (FMS), integrated manufacturing systems (IMS), computer integrated manufacturing (CIM)	1.66	1.56	1.36	1.24
G08C17/02	Arrangements for transmitting signals characterised by the use of a wireless electrical link -> using a radio link	0.51	0.50	0.44	0.40
G06F15/16	Digital computers in general; Data processing equipment in general -> Combinations of two or more digital computers each having at least an arithmetic unit, a programme unit and a register, e.g. for a simultaneous processing of several programmes	0.13	0.07	0.04	0.01
H04B7/26	Radio transmission systems, i.e. using radiation field -> for communication between two or more posts -> at least one of which is mobile	6.42	2.80	2.04	1.66
H04L12/26	Monitoring arrangements; Testing arrangements	1.24	1.22	1.14	1.05
H04L12/28	Data switching networks -> characterised by path configuration, e.g. LAN (Local Area Networks) or WAN (Wide Area Networks)	211.74	102.54	47.09	36.97
H04L29/06	Communication control; Communication processing -> characterised by a protocol	1.31	1.25	1.17	1.14
H04L29/08	Communication control; Communication processing -> characterised by a protocol -> Transmission control procedure, e.g. data link level control procedure	31.91	17.96	12.73	9.97
H04W72/04	Local resource management, e.g. selection or allocation of wireless resources or wireless traffic scheduling -> Wireless resource allocation	33.83	12.33	6.74	3.38
H04W84/18	Network topologies -> Self-organising networks, e.g.ad hoc networks or sensor networks	7.81	4.70	3.33	1.66

*BM-PAI – *Bhushan Mishra Patent Activity Index* – named after its creators

As can be seen in the above table, the PAI for IPC classes H04L12/28 (Data switching networks -> characterized by path configuration, e.g. LAN (Local Area Networks) or WAN (Wide Area Networks)); H04L29/08 (Communication control; Communication processing -> characterized by a protocol -> Transmission control procedure, e.g. data link level control procedure); and H04W72/04 (Local resource management, e.g. selection or allocation of wireless resources or wireless traffic scheduling -> Wireless resource allocation) are above 2.0 for years 2014, 2015, 2016 and 2017, indicated in green.

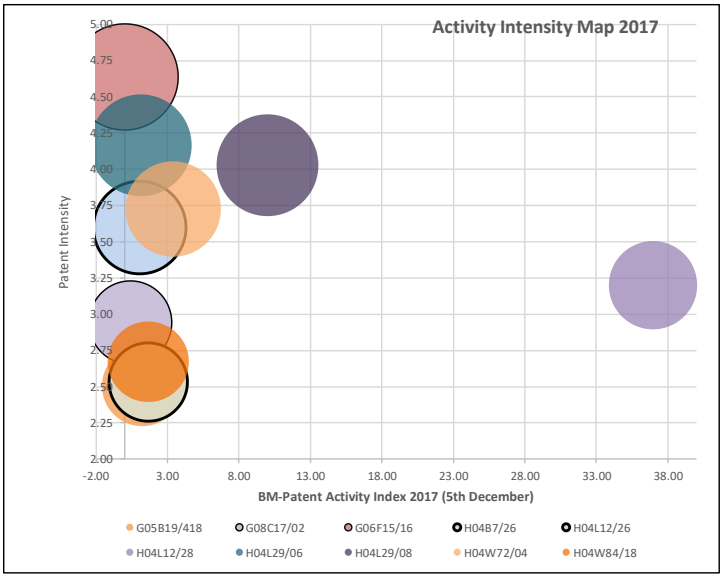
The PAI for H04B7/26 (Radio transmission systems, i.e. using radiation field -> for communication between two or more posts -> at least one of which is mobile); and H04W84/18 (Network topologies -> Self-organizing networks, e.g. ad hoc networks or sensor networks) is above 2.0 for years 2014-2016, indicated in green, and below 2.0 for the year 2017, indicated in amber. Similarly, for the IPC class G05B19/418 (Programme-control systems -> electric -> Total factory control, i.e. centrally controlling a plurality of machines, e.g. direct or distributed numerical control (DNC), flexible manufacturing systems (FMS), integrated manufacturing systems (IMS), computer integrated manufacturing (CIM)); H04L12/26 (Monitoring arrangements; Testing arrangements); and H04L29/06 (Communication control; Communication processing -> characterized by a protocol), the PAI is below 1.0 for years 2014, 2015, 2016 and 2017, indicated by amber.

Further, the PAI for G08C17/02 (Arrangements for transmitting signals characterized by the use of a wireless electrical link -> using a radio link); and G06F15/16 (Digital computers in general; Data processing equipment in general -> Combinations of two or more digital computers each having at least an arithmetic unit, a programme unit and a register, e.g. for a simultaneous processing of several programmes) is red (below 1.0) for the years 2014-2017. This implies that the number of Patent

Applications being published in the preceding 5 years (inclusive of current year) *remains less* than the number of Patents being granted. This indicates a reducing Invention activity in the specific domain. Thus, it can be concluded that IPC domains G08C17/02, and G06F15/16 are seeing reducing Invention Activity and has low invention velocity from 2010 to 2017.

H04L12/28, H04L29/08, and H04W72/04 are the prominent IPC classifications in the Internet of Things (IoT) technology which talks about ***data switching networks, communication control, and wireless resource allocation*** *respectively. The inventive activity in H04L12/28 was higher in the year 2014, since then the patent activity has been reducing as the number of Patents being granted has started increasing. Further, the inventive activity in H04L29/08, and H04W72/04 was also higher in the year 2014, since then the patent activity has been reducing. However, the inventive activity of H04L12/28 is still higher than other key IPC classes.*

Activity Intensity Maps of Top 10 Internet of Things (IoT) IPC classes in the year 2014 and 2017

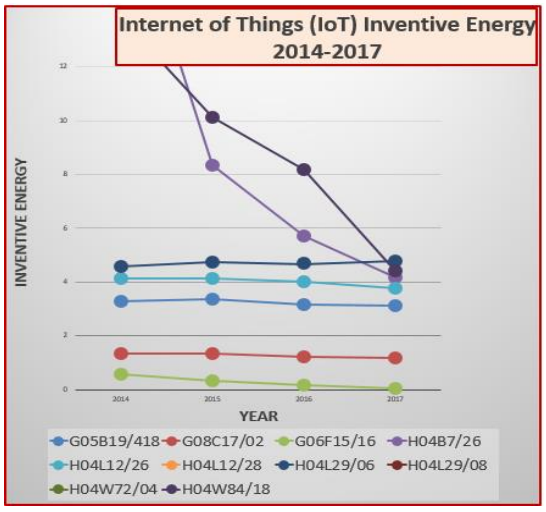


Activity Intensity Map (**AIM**) of a set of IPC classes is a Crafitti proprietary visualization of intensity in terms of a number of patents granted and patent applications published, and inventive activity in terms of relative pace of patent applications and granted patents in any IPC domain. For any year say 2014, these indices include a measure of yearly averages of last five years of a number of applications published and patents granted. For example, for 2014, these indices use data from years 2010, 2011, 2012, 2013 and 2014.

Internet of Things (IoT) Inventive Energy of Top 10 IPC classes

Inventive Energy for the year 2014 for IPC class G05B19/418 is simply a product of Patent Activity Index for the year 2014 (in this case a value of 1.66) and Patent Intensity for the year 2014 (in this case a value of 1.97). The Inventive Energy for the year 2014 for IPC domain G05B19/418 comes out to be 1.66 x 1.97 = 3.27, as shown in the Table. In general, the Inventive Energy of IPC class H04L12/28 (Data switching networks -> characterized by path configuration, e.g. LAN (Local Area Networks) or WAN (Wide Area Networks)) is highest among these top 10 IPC classes.

IPC Domain	Patent Activity Index				Patent Intensity				INVENTIVE ENERGY			
IPC	BM-PAI 2014	BM-PAI 2015	BM-PAI 2016	BM-PAI 2017	2014	2015	2016	2017	2014	2015	2016	2017
G05B19/418	1.66	1.56	1.36	1.24	1.97	2.17	2.33	2.51	3.27	3.38	3.18	3.12
G08C17/02	0.51	0.50	0.44	0.40	2.60	2.68	2.79	2.94	1.34	1.34	1.23	1.19
G06F15/16	0.13	0.07	0.04	0.01	4.51	4.56	4.60	4.64	0.58	0.32	0.17	0.06
H04B7/26	6.42	2.80	2.04	1.66	2.94	2.98	2.81	2.53	18.90	8.34	5.72	4.19
H04L12/26	1.24	1.22	1.14	1.05	3.32	3.40	3.50	3.60	4.12	4.15	4.00	3.78
H04L12/28	211.74	102.54	47.09	36.97	2.89	3.08	3.21	3.20	612.03	316.13	151.12	118.27
H04L29/06	1.31	1.25	1.17	1.14	3.48	3.79	4.01	4.17	4.56	4.72	4.68	4.77
H04L29/08	31.91	17.96	12.73	9.97	2.96	3.50	3.82	4.03	94.59	62.84	48.64	40.16
H04W72/04	33.83	12.33	6.74	3.38	3.28	3.45	3.61	3.72	110.99	42.53	24.35	12.60
H04W84/18	7.81	4.70	3.33	1.66	1.77	2.15	2.45	2.67	13.81	10.11	8.17	4.42



Key Findings

Due to its inherent simplicity and utilization of substantial information on published and granted patents, the present study on the inventive energy provides a de facto standard for enterprises active in Internet of Things (IoT) to evaluate the front edge of technology in various applications of the Internet of Things (IoT).

IPC class on the data switching networks; characterised by path configuration, e.g. LAN or WAN (H04L12/28) has seen the tremendous inventive energy in the 2014-2015 Index. Other two prominent IPC classes on communication control (H04L29/08), and Wireless resource allocation (H04W72/04) have also been quite active among the IoT enthusiasts and R&D teams.

One of the findings from the present inventive energy study is that the patenting activity was higher in the IoT domain in year 2014 and 2015. Further, there is a decrease in the patent activity in the Self-organising networks, e.g. ad hoc networks or sensor networks which was higher in the year 2014-2016. However, the filing trend in this domain is relatively better than the IPC H04B7/26 which talks about *radio transmission systems, i.e. using radiation field -> for communication between two or more posts, at least one of which is mobile.*

Further, the reduction in Inventive Energy of H04L12/28 from 2014 value of nearly 612.03 to the value of 118.27 in the year 2017, *indicates the trend of Patents grants has started in the period that typically brings down the Inventive Energy as it is a function of the ratio of applications published and a patent granted for the particular year.* Furthermore, the present inventive energy study identified that inventors are active in the implementation of the "IoT aware" technology majorly in features related to end devices to collect data or respond to the controls; wireless network protocols, communication systems; and applications that make use of the collected data.

IPC classes with high Inventive Energy typically will have higher business potential and growth in the Internet of Things (IoT) technology. The Inventive Energy can be utilized to create Internet of Things (IoT) Inventive Strategy to find problems in high inventive energy IPC classes. This can be a leading indicator for not only any startup or disruptor but also to existing patent owners to expand and strengthen their portfolio through this guidance rather than letting serendipity and opinion about future guide their inventive effort.

As the patent examiner not only evaluate the patentability of the corresponding technology but also assess the legal aspects of the filed patent application at various levels of scrutiny before granting the patent, therefore, patent grant trends identified by the present inventive energy study in the Internet of Things (IoT) technology will enable the decision maker with the due-diligence aspects of the Internet of Things (IoT) technology.

Any organization willing to invest in the Internet of Things (IoT) technology can utilize invention energy metric in general and this study in particular, as it automatically takes care of three major inputs required

to understand the state of the art of Internet of Things (IoT) technology – Patent Applications, Granted Patents and Specific IPC classes relevant to Internet of Things (IoT) technology in a composite metric.

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