Big Data Management under Internet Engineering and Information Security Threat

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***Abstract*—Big Data is characterized by 4Vs, namely Volume, Velocity, Variety and Veracity. Information security and data protection issues are magnified by these features. Hackers through Cyber Attacks deprive the value of Big Data. Hence, private and public sector should be ready for Big Data management and face its inherited security threat. This Paper analyzes the security threat of the contemporary IT infrastructure and proposes security solutions for possible Cyber Attacks.**

***Index Terms*—Big Data, Cyber Attack, Information Security, Security Solution**

I. Introduction

Data is said to be the new gold of this digital age (Goldsmith, 2017). The term Big Data refers to the massive amounts of digital information companies and governments collect about us and our surroundings (CSA, 2012). It has become crucial for business organizations and government bodies to gain actionable insights (Figure 1) for policy making, efficiency enhancement and community engagement (Sou, 2017).

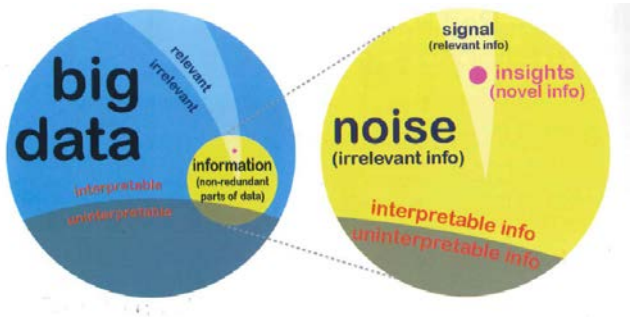

Fig. 1. Big Data transformed to Insights

Liedtke (2015) quotes that Big Data represents a situation where we have significantly more data than usual, for instance, a database containing 50,000,000 rows and 75 columns – terabytes. This is not a useful definition because traditional statistical methods can still be used and it does not adequately reflect what is happening in the data management.

Liedtke (2015) also quotes that Big Data represents a situation involving a large amount of data consisting of multiple data types sometimes arriving real-time from multiple sources requiring exploratory data analysis and integrative analytical methods for problem-solving and problem-discovering. This is a more useful definition consistent with what is happening in the Big Data management and it suggests the need for new management techniques and skills.

Big Data is characterized by its four features: (1) Volume, (2) Velocity, (3) Variety, and (4) Veracity (Linuxpilot, 2015). Information security and data protection issues are magnified by these features (Sou, 2017) of Big Data (Figure 2). Therefore, traditional security mechanisms, which are tailored to securing small-scale static data, are inadequate. Either private or public sector should be ready for Big Data management and face its inherited security threat.

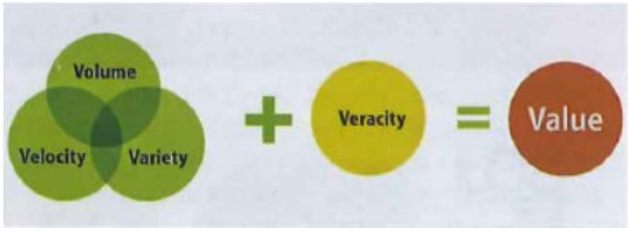

Fig. 2. Four Vs of Big Data

II. Research Methodology

This Paper studies the characteristics of Big Data and review the Cyber Attacks in the last decade. Author of this Paper is a registered United Kingdom Information Technologist and Diagnostic Engineer. Applying diagnostic engineering skills and expert opinion, he tries to analyze the security threat of the contemporary information technology infrastructure.

With reference to ISO 27001: 2015 and best trade practice, this Paper also proposes security solutions for possible Cyber Attack on Big Data. Benchmarking business organizations and government departments in some countries, the author proposes information technology solutions to address security issues surfaced in the prevailing Cyber Attack.

III. Case Study 2016

Information Systems Audit and Control Association (ISACA) is an independent, nonprofit, global association. It is engaged in the development, adoption and use of globally accepted, industry-leading knowledge and practices for information systems. ISACA once conducted a global survey in 129 countries. The Survey revealed that only 38% of

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respondents were prepared for a Cyber Attack. Ironically, 83% of respondents believed that Cyber Attacks are amongst the top three threats at the corporate level.

A. *Asian Government Cases*

In 2016, two agencies and four functional departments of the Government of Hong Kong Special Administrative Region respectively encountered Cyber Attacks (ORIENTAL News, 2016 & SINGTAO News, 2016):

✧ Customs and Excise Department
✧ Department of Health
✧ Food and Environmental Hygiene Department
✧ Marine Department

One of the foregoing government departments has implemented ISO 27001 for 16 years. It maintains the Quality and Information Security Management System (QSS) which meets the requirements of the ISO 9001:2000 and ISO 27001:2005 standards. However, it becomes a victim of Cyber Attack (Figure 3) (Sou, 2017).

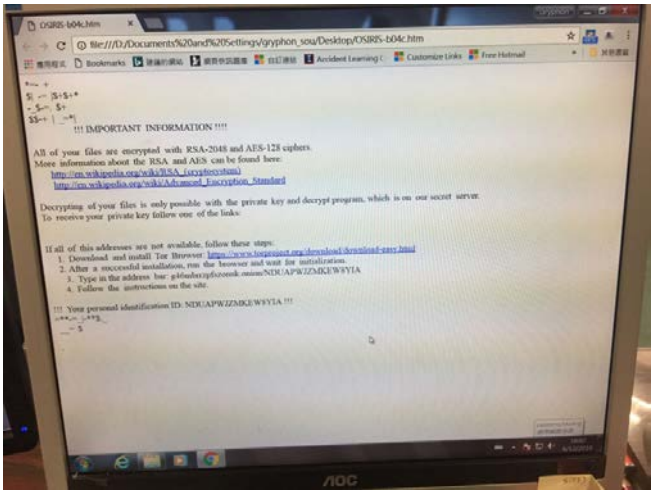

Fig. 3. Cyber Attack on a Government Department

During and after a Cyber Attack by the end of 2016, its firewalls and virus scanning software could not alert the users. The malware attacked the Hard Disk of a terminal with Universal Serial Bus Portable Drives and so forth SHARED Folders through the departmental and local network.

Thousands of data files such as *.doc, *.xls, *.jpg, *.pdf were maliciously encrypted with RSA-2048 and AES-128 ciphers. Technicians of its IT department tried to diagnose the infected Terminal by remote access but failed to sort out the problem. Users were advised to isolate the infected Terminal for on-site inspection.

On the following day, a Technician was deployed to scene and inspect the infected Terminal. After thorough checking, the Technician could not locate the Ransomware and restore the encrypted files. He elected to clone the hard disks of the Terminal and re-install its Operating Software and Applications. Naturally, all the encrypted data files could not be restored.

Such situation surfaced the vulnerability of its existing information technology infrastructure. The malware unknowingly circumvented regular scanning of its Symantec Endpoint Protection software and other information technology measures in place. The hackers circumvented the scanning software (Figure 4) and asked for 3 Bitcoins (1 BTC = USD1,000 in December 2016) as ransom (Sou, 2017).

Fig. 4. Scanning Software of the Victimized Department

Diagnosing the architecture of the above Scanning Software, the infection details would appear in the results list if the client detects a virus during the scan. (Note: If the software detects a large number of viruses, spyware, or high-risk threats, an aggressive scan mode engages. The scan restarts and uses Insight lookups.

When a virus is detected, the client tries to complete the designated action (Table I). If the action fails, the client performs the second action that was designated for that type of virus and scan. Further, the client can right-click on the name of a detected risk to display a list of post-scan actions. However, not all actions apply to every type of risk (Sou, 2017).

In Cyber Attack by Ransomware, the malware itself may be the newest or tailor-made for the victim. Therefore, the signature based architecture of a scanning software fails to detect it. When it successfully evades from the scanning, the designated actions would be inapplicable. After all, quarantine records have no audit trails of the malware and infected files.

TABLE I
Designated Action of Scanning Software

Option	Description
Exclude	Ensures that future scans ignore the virus or risk.
Clean	Removes the virus from the infected file. If the client successfully cleans a virus from a file, you don't need to take any other action. Your computer is free of viruses and is no

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Option	Description
	longer susceptible to the spread of that virus into other areas of your computer. When the client cleans a file, it removes the virus from the infected file, boot sector, or partition tables. This removal process eliminates the ability of the virus to spread. In some instances, the cleaned file might not be usable. This unusable state is a result of the virus infection and not a result of the clean action. Some infected files cannot be cleaned.
Delete Permanently	Deletes the infected file from your computer's hard drive. Use this action only if you can replace the file with a backup copy that is free of viruses or security risks. After the file is permanently deleted, it cannot be recovered from the recycle bin. Note: Use this action with caution when you configure actions for security risks, because deleting security risks might cause applications to lose functionality.
Undo action taken	Reverts the action that the client performed on the detected risk. This reversal is not always possible. For example, the client cannot restore a file that it deleted.
Move to Quarantine	Does one of the following: ✧ For viruses, moves the infected file from its original location to the Quarantine. Infected files within the Quarantine cannot spread viruses. ✧ For security risks, moves the infected files from their original location to the Quarantine and tries to remove or repair any side effects. Quarantine contains a record of all actions that were performed. This record lets you return the computer to the state that existed before the client removed the risk.
Properties	Displays more details about the detected risk.

Apart from four government departments, two Hong Kong government agencies were also attacked in August 2016. The China-based group APT 3 targeted them with "spear-phishing" attacks, in which e-mails with malicious links and attachments containing malware were used to access their computer networks. An American information technology firm was subsequently hired to identify attackers.

The government agencies remained anonymous to avoid shining a spotlight on the victims. The Office of Government's Chief Information Officer (OGCIO) confirmed that it had been informed about the hacks. "Relevant security measures had already been put in place to block the suspicious e-mails," it said in a statement. "So far, there is no security incident report from the two concerned departments (agencies)."

B. Healthcare Industry Cases

Ransomware is not a new malware in Cyber Attack but its growth throughout 2016 has made its prevalence known around the world. Organizations in the private and the public sectors were victimized. A July 2016 report revealed that the healthcare industry was attacked significantly harder by Ransomware than any other sector – 88 percent of attacks hit hospitals (Dietschye, 2016 & Green, 2016).

Becker's Hospital Review (2016) reported that 12 healthcare-related Ransomware Attacks in six months. With reference to Solutionary's Security Engineering Research Team Quarterly Threat Report Q2/2016, 94 percent of attacks on healthcare organizations are linked to a specific variant of malware called Cryptowall.

In February 2016, a Los Angeles hospital paid 40 Bitcoins of digital currency (USD17,000) to Ransomware hackers (The Guardian, 2016). Federal Bureau of Investigation often discourages victim to pay the ransom as it would encourage hackers. Hackers always customize the ransom for each victim and set them just low enough to seem palatable, if a bit painful (The Guardian, 2016).

In the Los Angeles case, the President and Chief Executive of the Hollywood Presbyterian Medical Center said, "The quickest and most efficient way to restore our systems and administrative functions was to pay the ransom. … In the best interest of restoring normal operations, we did this." (Yadron, 2016).

In May 2016, Kansas Heart Hospital became the second healthcare organization in America which publicly stated that it had paid the ransom. Hackers collected ransom from the Hospital but did not unlock all the data and then demanded more money.

President of Kansas Heart Hospital told the media that the first ransom was "a small amount" (Siwicki, 2016). However, he declined to pay the second ransom as it was not a wise move. He added that his hospital was aware of the looming ransomware threat and had a plan in place, highlighting that many organizations do not really know how to respond to a Cyber Attack.

IV. Big Data Security Challenges

Cloud Security Alliance (CSA) highlighted the top ten Big

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Data specific security and privacy challenges (CSA, 2012). Experts of CSA interviewed the Alliance members and surveyed security practitioner-oriented trade journals to draft an initial list of high-priority security and privacy problems, studied published research, and arrived at the following top ten challenges (CSA, 2012):

1. Secure computations in distributed programming frameworks
2. Security best practices for non-relational data stores
3. Secure data storage and transaction logs
4. End-point input validation or filtering
5. Real-time security or compliance monitoring
6. Scalable and compostable privacy-preserving data mining and analytics
7. Cryptographically enforced access control and secure communication
8. Granular access control
9. Granular audits
10. Data provenance

To study information security threat, we shall focus on Item 5. Real-time security monitoring has always been a challenge, given the number of alerts generated by the security tools. These alerts lead to many false positives, which are mostly ignored or simply "clicked away", as data users cannot cope with the shear amount (CSA, 2012). This problem might even aggregate with Big Data, given the 4 Vs (Volume, Velocity, Variety and Veracity) of data streams.

However, Big Data technologies might also provide an opportunity, in the sense that these technologies allow for fast processing and analytics of different types of data. Which in its turn can be used to provide, for instance, real-time anomaly detection based on scalable security analytics (CSA, 2012).

With real-time security monitoring, we attempt to be notified at the moment a Cyber Attack takes place. In reality, this will not always be the case. For instance, new attacks, missed true positives are difficult to be monitored.

For investigation of a missed Cyber Attack, we need audit information. This is not only relevant because we want to understand what happened and what went wrong, but also because of compliance, regulation and forensic reasons. In this regard, auditing is not something new; but the scope and granularity might be different and should keep pace with the trend of information security threat.

A. Advanced Persistent Threats

Gartner (2012) said, "Organizations face an evolving threat scenario that they are ill-prepared to deal with advanced threats (Figure 5) that have bypassed their traditional security protection techniques and reside undetected on their systems.". Since 2012, Advanced Persistent Threats (APTs) have become more prevalent. APTs targeted at critical infrastructure. They were persistent and difficult to be detected. APTs spread via LAN as well as USB.

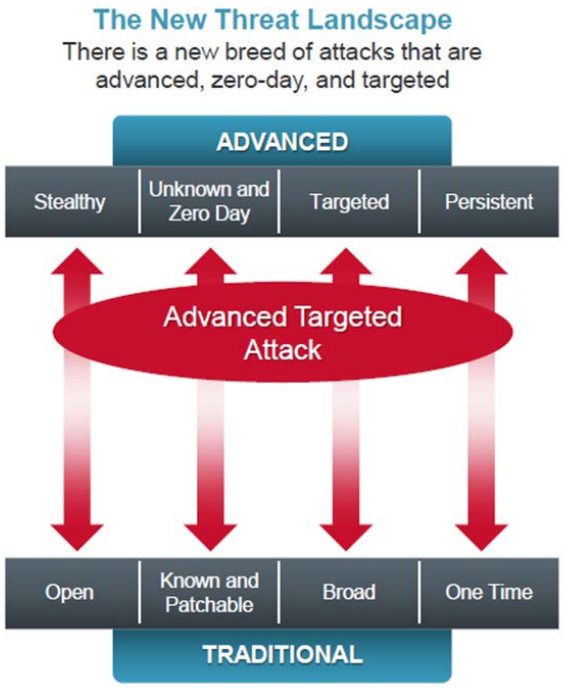

Fig. 5. Contemporary Information Security Threat
(This diagram is reproduced with the permission of iCON Business Systems Ltd / FireEye, Inc.)

Nowadays, APT utilizes advanced techniques and/or malware that is unknown, targeted, polymorphic, dynamic and personalized. It uses zero-day exploits, commercial quality toolkits and social engineering. It often targets IP, credentials and often spreads laterally throughout network. Ransomware is a typical APT.

Facing the new threat landscape, typical security architecture (Figure 6) failed to tackle. In other words, existing threat intelligence is lack of automation from the basic threat intelligence to threat fingerprint.

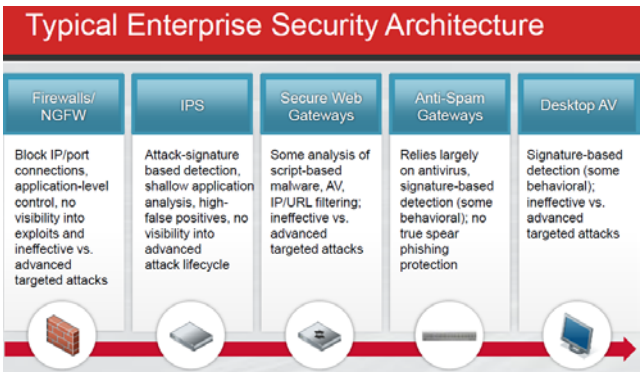

Fig. 6. Typical Enterprise Security Architecture
(This diagram is reproduced with the permission of iCON Business Systems Ltd / FireEye, Inc.)

The above illustration surfaces that typical security architecture in most information technology infrastructure is inadequately tackling APT like Ransomware. Terminals have access to the internet (hyperlinks) and internet-mail or web-mail servers. They are naturally exposed to APTs.

Though ISO 27001/2:2013 is a good global standard to

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follow for information security and privacy (Villanustre, 2014), data users habitually use their "own" USB Thumb Drives on the office terminals as some brands of Portable Drives can cheat the corporate computer systems. Regardless of rules and regulations, a Whitelist Portable Drive System easily collapses within an organization with mass data users.

B. International Standards for Information Security

Humphreys (2015) of International Organization for Standardization (ISO) emphasizes, "To ensure security in today's digital landscape, all organizations, irrespective of size should put in place a management framework as a starting point to manager cyber risks. ISO/IEC 27001 was designed to help organizations do just that. The standard is the world's 'common language' when it comes to assessing, treating and managing information-related risks.".

ISO/IEC 27000 series were revised in 2015. They formed part of the ISO/IEC 27001 "cyber-risk toolbox" to help keep information security threat in check (Lazarte, 2015). To name a few but not all, the following international standards are of referential value in Big Data management and information security threat mitigation.

Integrated Solutions for Services (ISO/IEC 27013)

More organizations are choosing to combine an information security management system (ISO/IEC 27001) with a service management system (ISO/IEC 20000-1). An integrated system means an organization can efficiently manage the quality of its services, handle customer feedback and solve problems, whilst keeping information (data) safe.

ISO/IEC 27013 offers a systematic approach to facilitate the integration of an information security management system with a service management system. It results in lower implementation costs and avoids duplication efforts in certification audit.

Detecting and Preventing Cyber Attacks (ISO/IEC 27039)

How can organizations detect and prevent cyber intrusions to their networks, systems and applications? Best trade practice shows that they must be able to know when and how an intrusion occurs. They should also be ready to identify what vulnerability is exploited and what controls should be implemented to prevent recurrence of similar intrusion in store. One way to do this is through an Intrusion Detection and Prevention System (IDPS).

ISO/IEC 27309 gives guidelines to prepare and deploy an IDPS, covering such crucial aspects as selection, deployment and operation. The standard is particularly useful in today's market where there are many commercially available and open-source IDPS products and services based on different technologies and approaches.

V. Findings

In short, internet access, email and unauthorized portable drives imposed risks to an organization. APTs possible damage to its information technology infrastructure and Big Data could be disastrous. In such circumstances, we should consider addressing APTs in the most realistic manner. Considering multiple stages of an Attack Cycle and Multi-Flow Virtual Execution (MVX), the Author finds that there is actually information security solution for APTs.

Benchmarking other victimized government departments and business organizations, the Author appraises the POC (Proof of Concept) of the FireEye Advance Threat Protection Architecture. Diagnosing FireEye architecture and hardware/software engineering, its concept of "behavioral" Malware Protection System (MPS) as an IDPS (Figure 7) is viable. Its inline blocking and quarantine available across MPS portfolio can:

- ✧ block inbound zero-day web attacks
- ✧ block multi-protocol call-backs
- ✧ quarantine malicious zero-day emails
- ✧ quarantine malicious zero-day files
- ✧ mitigate risk of data exfiltration
- ✧ provide highly actionable information for timely incident response.

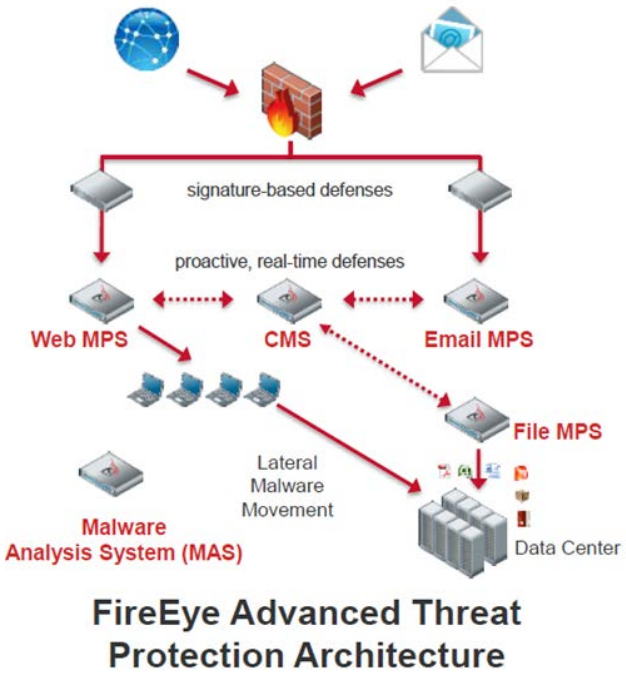

Fig. 7. Intrusion Detection and Prevention System
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Conclusion and Recommendations

This Case Study reveals that MPS hardware can tackle information security threat. Capacity of hardware can cater for the information technology operational needs (100 users @ 20 Mbps – 10,000 users @ 1 Gbps) of Small-and-Medium Enterprise to transnational enterprises. An American hardware manufacturer has global credentials. Its product has

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the following key features:

- ✧ Detect inbound 0-day and customs malware via virtual machine analysis
- ✧ Track outbound call-backs and subsequent malicious payloads
- ✧ Extremely accurate detection with near-zero false positive

In America, it also supplies 10-Giga native solution. If other global hardware manufacturers are supplying the same or kindred MPS, they are also of referential value to prospective users. In conclusion, this is a viable information security solution to rebut the fallacy of *"even the most powerful scanning software fails to detect newest or customs-made virus or malware"*. To counter Cyber Attacks under internet engineering, we need professional software plus dedicated hardware for data protection. Otherwise, hackers would deprive the value of our data maliciously (Figure 8).

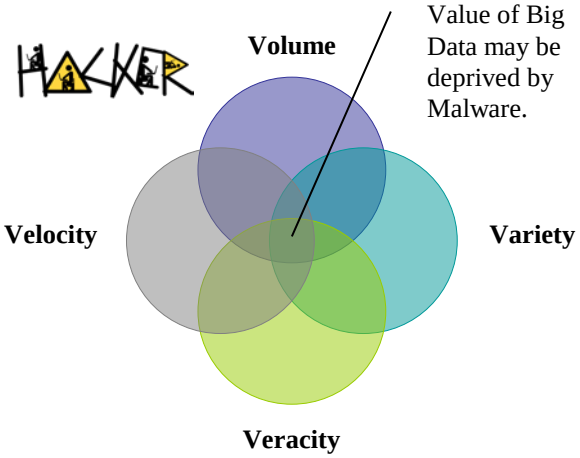

Fig. 8. Value of Big Data to be protected

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