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Ph.D. in Information Assurance*: An Indian Context—A Policy Framework Based on UGC Regulation*

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ABSTRACT

Information Assurance is an emerging field in Information Technology related subjects and responsible for the privacy and security. Information Assurance is broad and interdisciplinary than Information security, Information Technology security. And IT Security consist with few areas viz. areas of Web Security, Database Security, Network security and latest Cloud Security, Mobile Security, Multimedia Repository Security etc. The theories as well as practice of collection, organization, assuring and managing of information and knowledge are the core of Information Assurance field. Information Assurance deals with two sides viz. technological and manual information security and privacy solutions. Information Assurance is dedicated to the uses, processing, storage, and transformation of information with proper practice and principles. Information Assurance as a field of study available in developed countries. In United States itself it is available as Certificate, Diploma to Bachelors, Masters Program and even Doctoral Program. In US and many western countries availability of super specialty areas program i.e. the emerging and sub field of IT become common and important. Similar to this approach, Information Assurance is also available as a Doctoral Program. In India, academic program/ major in the sub fields and emerging areas of Information Technology is little rare and also in Doctoral program. Though the Ph.D. in Information Assurance has huge potentials. The paper highlighted the potentiality of Ph.D. in Information Assurance with model curricula based on Indian Ph.D. regulation 2016.

Keywords: Information Assurance, Ph.D.- Information Assurance, IT Management, IT Security, IT Education, Cyber Security, Indian Education, UGC Ph.D. Regulation

Information assurance is a concept, procedure and most emerging domain of IT for information privacy including security solution with the help of manual and computation technology. Information Assurance is uses different processes as Information Security for the right information and content to the right people and at right time keeping in mind the security issue. Hence, few issues viz. risk management, trust management are emerging issues in Information Assurance. Managerial policies as well as processes are very much important and authentic in Information Assurance. Information Security is very much close with the Information Assurance that deals both technology and manual content security with managerial point of view. Additionally it focuses on IT component's security viz web, database and network hence; Information Assurance is responsible for sophisticated information privacy and security. This requirement of Information Assurance led different programs in universities leading to BS/BSc/ MS/MSc degrees even Doctoral degrees.

Objective and Agenda

The core aim of this conceptual paper is include but not limited to the following—

- To learn about the basics of Information Assurance in simple sense.
- To learn about the features and characteristics of Information Assurance and allied fields.

- To learn about the function of Information Assurance that lead the field into a stream internationally.
- To learn about the basic degrees available on Information Assurance in International Universities.
- To know about the Doctoral Degrees available in International Universities and their major or nomenclature policy.
- To dig out and analyze the curricula of the Ph.D. in Information Assurance in International field.
- To find out the Indian Higher Education Systems specially the Engineering and Computing Education.
- To learn about the Indian Ph.D. Systems including available degrees and majors.
- To find out and design a possible model on Ph.D. in Information Assurance and allied field in Indian educational context.

Information Assurance: Characteristics

Information Assurance is an interdisciplinary field of study and emerged rapidly and deals with technology as well as and manual solution regarding security and privacy. Information Assurance is required in each and every type of organizations and institutions. Thus many international universities started Information Assurance program leading to Certificate, Diploma, PG Diploma, Masters, Doctoral programs. There are various requirements for the introduction of Information Assurance and these are possible to learn by studying following characteristics and features of the domain:

- Information Assurance is responsible for technological security and manual security both; but additionally, it deals with managerial solutions, policy and guidelines etc.
- Different security related matters like homeland security matters include the cyber terrorism, cyber war etc needed for Information Assurance practice.
- Information Assurance is also deals the mobile and allied security related means by the technology and manual systems.
- Different components of IT Security viz. network security, database securities (refer Fig. 1) etc are the core of technological side of Information Assurance and additionally managerial and legal affairs also need to learn.

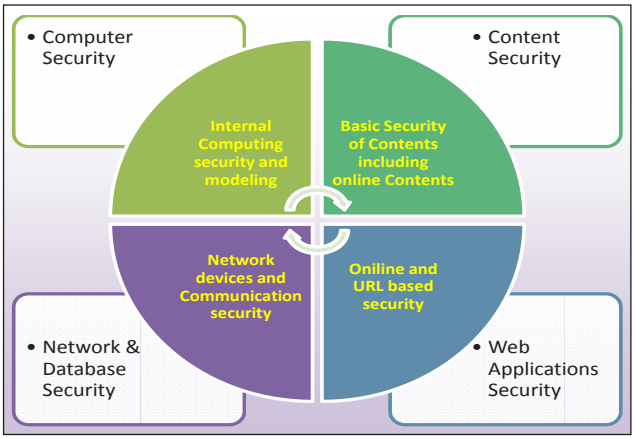

Fig. 1: Security dimensions in IT and Information Space

- Design, development as well as implementation of secure database and information management is required for sophisticated Information Assurance practice.
- Cloud security; trust management including complete infrastructure management are the core of sophisticated Information Assurance practice.
- Strategies of risk management are the core areas of healthy Information Assurance practice.
- Different kind of malicious attack is important issue in healthy Information Assurance practice. Prevention of hacking is important in Information Security solutions.
- Fraud management systems design, development and management are the core of sophisticated Information Assurance practice.

Thus, Information Assurance is required and useful in different type of organizations, institutions including profit making and non-profit making. Apart from private institutions in recent past Government institute also played a leading role for the introducing and implementing Information Assurance.

Information Assurance and Allied Education in with background of its requirement: Indian Context

In India, Computing Education is offered in two

platform viz. Engineering/ Technology and Science. The Engineering degrees are available with BTech/ BE & MTech & ME levels. Whereas Science program is available with B.Sc. & M.Sc.. However it is worthy to note that few universities also started international style of Science programs viz. B.S. & M.S. Hence Computing programs are available with these degrees. It is worthy to note that B.Tech./ M.Tech. & B.E. & M.E. Degrees are available with following subjects viz. –

- Computer Science and Engineering
- Information Technology
- Information Science and Engineering etc.

However, few are also offered Computer Science and Applications, Information Systems, Software Engineering.

As far as Science stream is concerned, popular nomenclature are as follows—

- B.Sc. /M.Sc. Computer Science
- B.Sc. /M.Sc. Information Technology
- B.Sc. /M.Sc. Information Science

In recent past many universities have started the program as a specializations with emerging areas viz. Network Technologies, Web Technologies, Software Technologies, Database Technologies, Multimedia Technologies etc. And Information Assurance is related to the field of Network Technology.

The field Information Assurance is rising rapidly and different technologies have been added into this. In recent past many similar nomenclatures have been added into this and among these few important are as follows—

- Information and Cyber Assurance
- Information Assurance and Security
- Information Systems and Information Assurance
- Information Assurance and Cyber Forensic etc.

In India, and few other countries, Information Assurance nomenclature is not available but the education and training is offered with other nomenclatures and little different concentration viz. IT Security, Information Security, Cyber Security, Cyber Forensic etc. And many of these has started program with Bachelors, Masters and Doctoral level. Among these few important Institutes and PG program are includes—

- Ganpat University, Gujarat , MSc-IT (Cyber Security).
- Mody University of Science and Technology, Rajasthan, MSc-Digital Forensic & Information Security.
- Institute of Trans-Disciplinary Health Sciences and Technology University, Karnataka MSc-CS (Cyber Security).

Though in Doctoral level in India, the subjects are not offered as specializations only few courses are offered. So, if any university offer Information Assurance as a research area, can opt for research or thesis on the area without scope of the detailed courses on Information Assurance or allied field.

Doctoral Education in India

The Doctoral Degrees in India mostly offered as Ph.Ds. The Ph.Ds before 2009 was only research work based that is by Thesis only. Since 2009, University Grants Commission (*The Apex Higher Education Commission and Regulatory body in India*) made compulsory few courses i.e. Research Methods, Computer Application and an Advanced Paper/Course of the subject. And then Research Work leading to Thesis submission.

Traditional Ph.D. in IT and Allied Fields

It is worthy to note that in India there is no scope of specializations like western countries. For example if one is interested to do Ph.Ds in Database or allied areas then only Thesis or allied research components (viz. papers, presentation etc) can be possible while internationally in academics Database and allied areas is available as Masters and Ph.D. level. So in India a candidate noted as Ph.D. in Information Assurance or Security can be considered as an expert of the field by a chosen area of study or topic only. But internationally Ph.Ds degrees on the fields may be available on detailed courses. For example if one is interested for the Information Assurance Ph.D., then few Core Courses or Specialization may be offered on a Technology based on Security and these may be Web Security or Network Security or Database Security or Cloud Security may be an area. Similarly, one can choose any Managerial areas on Security viz. Security Policy, Guidelines,

Framework, Challenges & Issues, Risk Management, Security Ethics etc.

Ph.D. in IA: International Look

As noted in previous section, the following are some example of International Universities (refer Table 1), offers wide range of courses on Information Assurance and allied areas—

Table 1: Shows the list of universities offering degrees in Information Assurance

Universities	Degree
Northeastern University	Ph.D. Information Assurance
The University of Dallas, Texas	Ph.D. Information Assurance
Capella University	Ph.D. Information Assurance & Cyber Security
The State University of New York	Ph.D. Information Science (Information Assurance)
The University of Maryland	Ph.D. (Accounting & Information Assurance)
Colorado Technical University	Doctor of Computer Science (Cyber Security & Information Assurance)
University of Fairfax	Doctorate in Information Assurance

As far as Courses are concerned, it includes the Core area of the Subjects, Then core area of research and specialization of the Information Assurance.

Table 2: Ph.D. program at Northeastern Universities in Information Assurance

Universities	Degree	Papers/ Courses
Northeastern University	Ph.D. Information Assurance	*Core Courses* ❍ Fundamentals of Computer Networking or Digital Communications ❍ Software Vulnerabilities and Security ❍ Network Security or Cryptography and Communications Security ❍ Security Risk Management and Assessment ❍ Cyberlaw: Privacy, Ethics, and Digital Rights *Any One Track* *Track: Network Security* Wireless Network Digital Signal Processing *Track: System Security* ❍ Computer Systems Or ❍ Computer Architecture Software Security Practices *Track: Policy* ❍ Security Management ❍ Security and Resilience Policy *Electives (Any 4)* ❍ Managing Software Development ❍ Machine Learning ❍ Machine Learning ❍ Information Retrieval ❍ Applied Probability and Stochastic Processes ❍ Fundamentals of Computer Engineering ❍ Information Theory ❍ Research Methods Or ❍ Empirical Research Methods *Dissertation* ❍ Dissertation 1 Or ❍ Dissertation Continuation (Final)

Ph.D. in IA and Other allied nomenclatures: The Way

Table 3: Ph.D. in IT and Computing (Tech) related subjects with Information Assurance Specialization

In Technology/ Engineering Stream
❍ Ph.D.- Computer Science & Engineering (Information Assurance)
❍ Ph.D.-Information Technology (Information Assurance)
❍ Ph.D.- Software Engineering (Information Assurance & Secure Coding)

As far as India is concerned, the Ph.D. program in Information Assurance may be offered as nomenclature viz. Ph.D.– Information Assurance (or any allied merged domain) or it may be as

a specialization in the allied subjects and here the Table 3 is depicted the proposed Ph.D. in Information Assurance as a specialization in Computing related subjects (in Engineering and Technology track); whereas Table 4 is depicted Information Assurance specialization in Computing and IT related subjects (in Science track).

Table 4: Ph.D. in IT and Computing (Science) related subjects with Information Assurance Specialization

In Science Stream
❍ Ph.D.- Information Science (Information Assurance)
❍ Ph.D.- Information Technology (Information Assurance)
❍ Ph.D.- Computer and Information Science (Information Assurance)
❍ Ph.D. - Computer Science (Computer & Information Assurance)

Ph.D. Information Assurance: A Proposed Model

Information Assurance is a broad and inter-disciplinary field, though the field is admissible as a specializations but it could also be offered as a full-fledged degree. As per the UGC norms the Ph.D. program should be consist with Coursework and Research Work. The Coursework is the Courses and Papers as described previously whereas Research Work leading to affairs on Thesis, Publications and Presentation. However, as per the norms laid down by the UGC there is no credit hour prescribed for the Research work except the Coursework. And the Coursework credit limit is Maximum 16. Hence in this proposed model Two Types of Courses are prescribed, first is Mandatory Courses and second, Add on or Additional Courses to get the knowledge and skill on diverse areas.

However, to get maximum utilization of the Information Assurance area and as a model Ph.D. in Information Assurance, instead of only 4 Papers/ Courses different Courses are proposed with unique and sophisticated education policy model. Here courses are categorized into following—

- ❒ Core Courses of the Broad Subject (One Course and one seminar totaling 4 Credit)
- ❒ Core Courses of the Information Assurance (One Course and one seminar totaling 4 Credit)
- ❒ Research Courses (Two Courses totaling 4 Credit and 2 seminar totaling 6 Credit)
- ❒ Specializations (One Course on 2 Credit)

Hence instead of One Subject Paper, Research Method and Computer Application paper is has proposed courses from diverse areas and point of strategy. Here Core Broad Subject course is refers to the field Information Technology (as Information Assurance is fall under this branch), and one general course has been recommended and here proposed title is 'Advancement & Trend in Information Science & Technologies' (3 Credit) and Seminar on the Course or allied area is 1 Credit. Information Assurance is a broad and established subject internationally and thus One paper directly on this has been recommended and categorized as Core Courses of Information Assurance and recommended paper is 'Information Security & Assurance: Basics & Trends' (3 Credit) and Seminar on the Course or allied area is 1 Credit. Additionally, one course from the specific area may be chosen and here proposed areas within Information Assurance is recommended as—

- ❒ Network Security
- ❒ Database Security
- ❒ Cloud and Advanced Web Security
- ❒ IT Security Policies

Thus in this proposed model all the areas have been covered ranging from Broad field 'IT' target field 'Information Assurance' and Specialization within the 'Information Assurance' and Research Courses. Here courses are proposed and fixed within 16 Credit including taught courses, seminar in all track.

Here as per International trend huge number of courses and papers are proposed and these are categorized within the same broad category—

- ❒ Additional Courses of the Broad Subject (Two Courses)
- ❒ Additional Courses of the Information Assurance (One Course)
- ❒ Additional Research Courses (Four Credit)
- ❒ Additional Specializations Courses (Six Courses)

It is important to note that in India, UGC has not mentioned about the Credit of the Research Work and thus it may depend on the institute. Few IITs,

Table 5: Poposed Model on Ph.D. in Information Assurance

Types of Courses	Courses	Credit	Nature
Core Courses of the Broad Subjects	Fundamentals of IT and Computing	4	Add On
	Advancement & Trend in Information Science & Technologies	3	Mandatory
	Innovations, Business in IT Sector	4	Add On
	Seminar 1	1	Mandatory
Core Courses of the Information Assurance	Information Security & Assurance: Basics & Trends	3	Mandatory
	Technologies in Information Assurance	4	Add On
	Seminar 2	1	Mandatory
Research Courses	Computing in Research	2	Mandatory
	Research Methods: Fundamentals	2	Mandatory
	Research Designing	4	Add On
	Advanced Research Methods	4	Add On
	Applied Research and Innovations	4	Add On
	Research Processes, Theory, and Practice in Information Technology	4	Add On
	Seminar 3	1	Mandatory
	Seminar 4	1	Mandatory
Specializations	**Network Security Courses**		
	❍ Network Security Basics & Advancement	2	Mandatory
	❍ Cryptography and Communications Security	4	Add On
	❍ Security Risk Management and Assessment	4	Add On
	❍ Wireless Network & Security	4	Add On
	❍ Cloud and Infrastructure Security	4	Add On
	❍ Database Security	4	Add On
	❍ Web Security	4	Add On
	Database Security Courses		
	❍ Database Security Basics & Advancement	2	Mandatory
	❍ Communications Security and Data warehousing	4	Add On
	❍ Security Risk Management and Assessment	4	Add On
	❍ Cloud and Big Data Security	4	Add On
	❍ Information Systems Privacy with Server Security	4	Add On
	❍ Network and Web Security	4	Add On
	❍ Advance Database Assurance with Firewall	4	Add On
	Cloud and Advanced Web Security Courses		
	❍ Cloud and Advanced Web Security: Basics & Advancement	2	Mandatory
	❍ Designing and Securing Cisco Cloud	4	Add On
	❍ Cisco Cloud and Enterprise Solutions	4	Add On
	❍ Cloud and Big Data Security	4	Add On
	❍ Information Systems Privacy with Server Security	4	Add On
	❍ Advanced Network Security Solutions (Cisco & Microsoft)	4	Add On
	❍ Advance Database Assurance with Firewall	4	Add On
	IT Security Policies Courses		
	❍ Information Assurance: Social and Organizational Context	2	Mandatory
	❍ IT Security Policies: International Context	4	Add On
	❍ Cyber Laws in India	4	Add On

	❍ Cyber Crime and Society	4	Add On
	❍ Ethics and Digital Right	4	Add On
	❍ Manual Content & Its Security	4	Add On
	❍ Planning and Formulation of IT Security	4	Add On
Thesis/ Dissertations		25	

and IIMs fixed Credit for Research Work also. Here as far as this work is concerned, Credit work is proposed '25'. However that may not offered or mentioned. Here total 5 Courses are within Mandatory list and 13 Courses from the Add On list. So total 18 Courses may be opted by the interested candidate.

Issues with Solutions: Indian Context

We already learned that Indian education sector is little different with other countries. Here combination of both UK and US model followed. As far as Ph.D. is concerned initially (up to 2009) only Thesis model was followed and then Few Basis courses (2-3) started since 2009 like US universities. But US and follower countries offers huge Courses on a Specializations (so that the educated hold the knowledge of Masters of the concerned Specialization). More clearly, if an IT Graduate is interested for Ph.D. in Information Assurance then the MSc/MS Information Assurance courses normally recommended. So in this proposed model all the required courses of a given topic has been strategically listed as Mandatory and Add On Courses to fly as per international trend.

Educational Policies

For this study and policy framework, the current UGC regulation (India) has been followed and here syllabus of international universities is reviewed to learn about the current strategies adopted by such universities. As in India already maximum 16 Credit Coursework has been fixed so that in proposed model also mandatory courses proposed with 16 credit and additional courses are offered. Here 1 Credit is equivalent of 1 Hour lecture per week. And Marks distribution of each Courses is fixed 100 (total 5 courses) and 4 Seminar Presentation (each carry 50 Marks).

Hence total Coursework Marks proposed 500 (Courses) + 200 (Seminars) i.e. 700 (Seven Hundred). And there is no provision of Thesis Credit and Marks as per the UGC Norms but for Seminar Presentation & Proposal (100 Marks/ 2 Credit), Pre Submission (100 Marks/ 2 Credit), Publication (100 Marks/2 Credit) and Thesis may credited 500 (19 Credits) Marks may be considered.. Total Ph.D. Information Assurance considering only Coursework Mandatory Marks is 700 and Research Work 800 Marks, totaling 1500 Marks. Credit wise that is proposed 16 +25 i.e. 41 Credit.

However, in the score card additional papers/ courses with Marks achieved must be noted to display the assessment of the candidature. Hence in this context, the total Marks for the Additional Courses will be 1300 and distribution will be as follows—

- ❒ Core Courses of the Broad Subjects (2 Courses; totaling 200 Marks)
- ❒ Core Courses of the Information Assurance (1 Courses; totaling 100 Marks)
- ❒ Research Courses (4 Courses; totaling 400 Marks)
- ❒ Specialization (6 Courses; totaling 600 Marks)

Here it is worthy to mention that, in the score card only Marks (of 1500) of the Additional Courses may be mentioned and ultimate result should be based on Mandatory Courses i.e. 16 Credit (as UGC specified maximum 16 Credit Courses and Research Work 20 Credit (optional, if institute desired for).

HR Availability

Availability of Human Resources is another important issue as Information Assurance is a broad field and combine with various subjects. For the additional subjects viz. Law, Society and Management related courses allied department may be suitable to offer and taught the program. Hence a collaboration is highly desired and important.

Wider Skill Potentialities

In the specialization (under the list of Add On courses), different areas have been proposed and mentioned based on current industrial

requirements. Here Network Security, Database and Web Security, Cloud Security are among the skill based specializations, whereas IT Security Policy has been proposed from the managerial perspective. Here the units, departments having skill based academic program may be useful to offer the additional courses.

Industrial Interaction

These days, Ph.Ds not only a study to work in the academia and many are interested to work in the industry and organizations and thus such skill based specialization may be suitable. And for this corporate tie-ups can be built as a industrial tour, training program, Internship etc as part of the additional programs.

Research Evidence regarding

As a highest degree, Ph.D. should be a place to learn about the research and publications; thus different components should be offered viz. Journal Papers, Event Presentations preferably International Conferences, Editorial Affairs etc.

CONCLUSION

Internationally the field Information Assurance is rising rapidly with its different area viz. Network Security, Database, Web Security including Mobile Security, Cloud Security etc whereas IT Security Policy is also another position to become Information Assurance Consultant, Information Security Policy Makers, IT Security Consultant, IT Security Manager. Indian IT academics is restricted to offer the program on Computer Science, Computer Application, and *Software Technology focused* IT Degrees. Hence already there is a shortage in skill manpower solutions in Information Assurance and Security domain. With a proposed Ph.D. in Information Assurance thus one can go to the academics for teaching and as the proposed program specified variety of courses from different categories and track thus the student can explore additional knowledge from this Ph.D.-IA Graduates. Moreover, the Ph.D.-IA Graduate can employ in the industries for the Security and Policy oriented job without doing MSc/MTech in the Information Assurance or allied areas. Here leading emerging technologies viz. Cisco, Microsoft, IBM, Check Point related skill may be incorporated.

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