1. Introduction:

Development of computers started with first generation in 1940s using vacuum tubes. From there on advances in hardware brought us to the level of VLSI where miniaturization achieved millions of processors to be packed into the size of an ant’s head which can perform millions of instructions in a second. The hardware evaluation thus has progressed fast from first generation vacuum tubes to second generation semiconductors to third generation of chips to the current fourth generation of VLSI. Further researches into new techniques are promising, not only in the areas of conventional materials like semiconductors, but also into other non-conventional methods of computing like bio-technology etc.

While the advances in hardware started much earlier and progressed immensely, the concepts of software started much later and growth has picked up during early 1980s and started exploding. The software has entered into every industry and started influencing every aspect of human life. The growth of software also has undergone into different generations or eras like the hardware growth, only differences being the many fold amount of increase in size (in terms of effort, number of applications and complexities of software products and custom built software) and the relatively short time of its explosion. The changes in software were so rapid that the very definition of illiterate has been redefined in mid 1990s as “those who are not educating themselves in acquiring the knowledge about the developments” from the old definition of “not able to read”.

1.1 Technology Development Versus Standards Evolution:

Conventional Engineering fields like Civil, Mechanical and Electrical have taken long time (Centuries starting beginning with the starting of industrial revolution in 17th Century) to evolve to the current levels of technology. Hence, the standardization in these fields also evolved slowly over centuries. Different countries developed different standards to meet their needs. It is World War II that has shown the need for development of international standards. World war-II has shown the loopholes in the manufacturing industry. The lack of
compatibility between the different standards adopted by different countries has become a trade barrier and this barrier has given birth to ISO in 1947. While the initial concentration of this world body was mostly in manufacturing and testing practices, soon the importance of processes was realized. Hence, ISO has started concentrating on developing process oriented standards and brought out the first generic standard ISO 9000 series in 1984. This standard is so generic that it can be applied by any industry, small or big, across the globe and for any engineering activity. Since the background to develop this standard is based on manufacturing, each of its clauses needed careful interpretation while applying to software. The standard itself revised in 1994, 2000 and 2008 since then each time improving towards more process orientation.

Similarly the early phases of software development are restricted to individual heroic efforts of developing custom built software. But soon the limitations of this approach are recognized and concentration on the software engineering as a set of processes gained momentum.

1.2 Explosive Growth of Computer industry and Software and evolution of quality standards

While the growth of conventional engineering spanned across centuries, the growth of computer technology exploded in few decades. The evolution of standards to judge quality of the computer technology was lagging way behind. Relatively the hardware standards took less time compared to software. While the software evolution started after some decades and exploded into many areas, the standardization of quality standards is still getting evolved.

Any lagging in the evolution of standards behind the technology development leads to defector standards. One such classic example is TCP/IP versus ISO standards for network protocols. By the time SIO has come out with its 7 layer standard, TCP/IP has advanced so much that it has been accepted as a de-facto standard and the manufacturers find it so difficult to switcher to ISO standards. Hence, mostly it remained as a theoretical standard.

Since the explosive growth of software has brought immense benefits it is also associated with numerous problems. The lagging and lack of proper standards to judge the software

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development capability has created huge problems. For organizations like DoD and NASA it has become almost a herculean task to determine the software quality development capability of different organizations making tall claims to develop the software as per their requirements. This has given birth to SEI at CMU with DoD funding that has come into existence in 1984. The main task of SEI is to suggest methods to DoD to determine the capability of software supplying organizations to develop required software with in the defined main parameters of quality, cost and schedule. To address this problem SEI started collecting best practices across the major software organizations and formulated these best practices into Capability Maturity Models (CMMs).

SEI has brought out the first CMM framework in 1995 and since then revised it many times and renamed it appropriately like CMMI for different engineering disciplines. Off late it brought a separate framework for services.

1.3 The birth of Audit and Assessment standards

Originally both ISO standards and CMMI framework were anticipated to be used for self improvement within the organizations. But, the explosive growth in demand for software has forced the organizations to off-load the software development work to other organizations. This has given immense opportunities for rising economies like India and many other developing countries to start developing software as service. The great advantage of availability huge technically qualified and mature human resources coupled with low labor costs and excellent English speaking capabilities in these countries have forced USA to offload the development of software work to these countries. The advantages reaped by USA by off-shoring have been felt by other developed counties like European countries who started following American model of off-shoring.

This has given birth to software stalwarts like Infosys, Wipro, TCS, Satyam, and HCL to name a few, and many more across the globe, while the ISO and CMMI standards address the process needs to develop software by these organizations, assessing the adherence to the defined processes cannot be just delegated as internal improvement tasks. The adherence to
these processes needs to be verified before multi-million contracts are awarded. Hence, assessing the adherence to different standards of software development processes has become a commercial activity. Thus ISO brought out the audits while SEI brought out assessment and appraisal standards. The accreditation bodies of these standards/frameworks like ISO and SEI cannot be equipped themselves to ascertain the adequacy of processes defined and level of adherence to these processes. This is due to sheer size of the number of software development agencies across the globe as well as the numerous projects and activities these organizations are involved with. As ISO and SEI cannot conduct these activities of process audits, many third party organizations have come up to fulfill this need which has become a commercial activity itself. The offspring of these activities given birth to many auditing and certification recommending bodies. Also, another offshoot of these developments is process consultancy which has taken birth from the advantage of vast software development experience gained by major software suppliers who had the benefit executing huge projects for different customers in different domains.

1.4 Emergence of Software Maintenance as Major Revenue Source

The software applications, once developed cannot remain static as the organizational business requirements will be continuously changing and there can be bugs hidden in the delivered software that will be shown much later in the usage lifecycle. These activities have evolved into huge maintenance projects themselves. But both ISO and CMMI standards that concentrate on development activities, have been deficient in addressing the maintenance requirements to the level for software development projects.

1.5 Emergence of Software Testing as Another Major Revenue Source

The software that is often developed through off shoring may have many hidden defects that will severely affect the business operations during life cycle of the software. Hence, independent testing has evolved as another major commercial activity. Again, the quality standards that are targeting for development like ISO and CMMI are not adequate to address pure testing projects.
1.6 Variety of Software Development Arrangements:

Apart from turnkey off-shoring of software activities, new trends have emerged in project execution models. This is mainly due to the diverse domains that needed software support to address their needs whereas service providers’ business domain knowledge is limited. Moreover, software service providers’ technical strengths in software development combined with best practices and domain strengths of the clients started getting combined in adopting different project execution models like ODC (Offshore development centers), dedicated development centers for clients, mixed models etc. Again the ISO and CMMI standards are all ill-equipped to address the needs of these emerging models.

Since new business models are still evolving in software industry, new domains are emerging and many new businesses are looking at software solutions, numerous standards have emerged that aim to build processes to different types of applications and to meet different kinds of customer needs. Figure-1 below shows some of these standards/frameworks:

![The Frameworks Quagmire](image)

**Figure-1: The Frameworks Quagmire**
(Source: Sarah A. Sheard “The Frameworks Quagmire, A Brief Look” Software Productivity Consortium, 2214 Rock Hill Rd, Herndon VA 22070, 2001)

This complex situation has lead to many issues that need to be researched and solutions found. Some of these problems are addressed in the “Objectives section” of this research proposal.