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Science and Engineering Research Council

Engineering Board - Information Technology Directorate

INFORMATION ENGINEERING COMMITTEE

STRATEGY FOR SOFTWARE ENGINEERING

Memorandum by the Alvey Director of Software Engineering

SOFTWARE ENGINEERING

1.   A strong domestic capability in the technology of building IT systems is the key to a leading position in the world market. Software is a fundamental component of IT systems and accounts for an ever increasing proportion of their cost. Correspondingly, the capability to design and build software in the most reliable and cost-effective way is a crucial element in establishing an important position in the world IT systems market.

2.   Today it is common practice to construct even large and application-specific systems using ad hoc techniques. The practicality of doing this is declining rapidly, as systems become more complex and the market becomes more competitive; the ad hoc approach is already showing signs of strain. Methods must change. Efficient production, an engineered approach to reliability, conformity with requirements, and economical development and operation must become the UK norm. The technology of reliable and cost-effective software generation is the emerging discipline of Software Engineering.

3.   The goals of the Alvey Software Engineering Programme are

a.   improved <u>quality</u> ie satisfying criteria such as performance, reliability, security, on-schedule delivery and meeting the needs of the user;

b.   improved <u>productivity</u> ie reducing cost, not just of the development but of the life-cycle as a whole, including maintenance and future evolution.

THE FOCUS: INFORMATION SYSTEMS FACTORIES

4.   The programme proposed to meet these goals is focussed on developing Information Systems Factories (ISFs). The aim is to establish by the end of the decade a lead in the UK's ability to provide ISFs. This will imply their widespread use. An ISF will be a computer system, both hardware and software, which provides an integrated set of tools for producing IT systems using software engineering techniques. It will be developed from successive generations of Integrated Project Support Environments (IPSEs), starting with a consolidated set of the tools available today. IT systems produced through the ISFs will meet the parallel requirements of efficient production and operation, and of improved reliability and performance, which the competitive market of the 1900s will impose.

5. On a broader scale, the programme - while focussing on ISFs - has a number of subsidiary objectives. Some of these will be achieved in the earlier stages of work. They include:

a. the promotion of existing software engineering tools through investment in development, distribution and training

b. the development of a methodology for quantifying and monitoring the resulting improvements in software productivity and quality

c. the initiation of substantial research into the next generation of tools and techniques. Of particular importance is the establishment of collaboration between the academic and industrial sectors, and associated infrastructure to support this collaboration.

STRATEGY : INNOVATION, INTEGRATION, EXPLOITATION

6. The Alvey SE strategy is based on the prediction that by 1990 software production will have ceased to be a cottage industry and will be a capital intensive industry.

7. Over the last 18 months, consultation involving over 400 people and organisations, has established that there is very strong agreement in industry, Government and academia on the technical direction that the SE programme should take ie quality and productivity will result from the ISF.

8. To ensure continuous benefit during the period preceeding the achievement of the ISF the SE strategy encourages intermediate levels of technology transfer by establishing a continuous 'pipeline' from research through development and into product prototype and marketing; this is encapsulated in the headings innovation, integration, exploitation.

9. _Innovation_ is the research and development to extend the understanding, theory, methodologies and techniques of Software Engineering. Of particular importance are formal methods of specification, verification and validation, measurement of quality and productivity, and reusable component techniques.

10. _Integration_ is the development of integrated methodologies and sets of tools for hardware and software development covering all phases of the system life-cycle to construct a series of progressively more powerful Integrated Project Support Environments with the long term aim of producing the Information Systems Factory (ISF). The ISF will contain sophisticated automated tools supporting advanced methods of system (hardware and software) development and maintenance.

11. _Exploitation_ is the action to ensure that existing methods are effectively used and their benefits gained by industry as a whole, and continuing efforts to bring the fruits of research out into industrial use, with the associated investment and training. The Software Production Centre, the National Quality Certification Centre and the Software Components Brokerage will be concrete Alvey Programme exploitation vehicles.

12. Further details of the strategy are given in figure 1, in the appendices to this paper and the documents listed in appendix D.

13. The SE Strategy has been approved by the Alvey Advisory Group on Software Engineering (27 October 1983), the Alvey Steering Committee (2 November 1983) and the SERC/IEC (9 November 1983).

STRATEGY	Innovation and Understanding	Integration and Implementation	Exploitation and Evaluation
Methods and Processes	Specification V & V Reliability Quality Metrics Reusability	Blend techniques into life cycle method for both hardware and software	Measure use of IPSE
Management	Models of development and maintenance processes and methods	Integrate development methods with management techniques	Evaluate use of IPSE
Environment	Influence on Productivity and Quality MMI, IKBS, DCS	Build IPSEs	Make IPSE available via Centres

Figure 1

APPENDIX A: INNOVATION

14. The three key points to be made about innovation are that

a. whilst the general directions in which innovation is needed are known it would be premature now to try to pick winners and ignore rival approaches;

b. research projects are often on too small a scale to provide an adequate testing ground for a new technique;

c. the scale of UK research must be increased to compete with our international rivals.

15. Thus the programme will back a number of promising approaches to (for example) specification, and test them out on life-size projects rather than attempt to evaluate them in terms of their apparent success in small-scale use. This approach not only offers a better change of selecting useful techniques, it also starts to bridge the 'development gap' by bringing research results out into a development environment.

16. The current list of research priorities includes:

a. Software Development Methods

- Formal Specification

- Verification and Validation

- Reusable Components

- Metrics

- Quality Assurance and Certification

b. Project Management

- planning and estimating

- progress and productivity measurement

- budgeting

- standards control

c. IPSE

- items already indicated above are relevant

- evaluation experiments to test changes in productivity and quality due to use of IPSE in the industrial context

- MMI, VLSI/CAD etc from other Alvey areas but relating to IPSE construction. The SE research programme will overlap significantly with other areas (this is a good thing) and the Alvey Directorate will ensure intraprogramme coordination.

APPENDIX B: INTEGRATION

17. The second element of the strategy, integration, provides the framework for the evolution of a full Integrated Project Support Environment (IPSE). An IPSE will contain a compatible set of tools based on a methodology for all phases of system development and operation, supporting both technical and management activities. Advanced IPSEs will also support multi-language developments allowing the system designer a choice of languages for programming and the ability to introduce reusable software components. Similarly, development in both hardware and software will be supported so that either may be chosen as the preferred implementation medium for particular system components. By comparison, tools that exist today are specific to particular stages of the system life cycle and are generally incompatible with each other.

The Programme will proceed as follows.

a. Commission development and creation of three generations of IPSE:

        1st)   )file
        2nd) generation IPSE   )database
        3rd)   )knowledge base

b. Versions of each generation of IPSE to be sited in SPC (section 22) and NQCC (section 23) and selected organisations where IPSE impact on quality and productivity can be monitored and reported.

c. Cooperate with and incorporate aspects of other Alvey areas towards ISF eg CAD for VLSI, high resolution displays, expert systems for programmers.

18. The first generation IPSE will be based on UNIX. Three IPSEs will be produced, each aimed at a different applications area. Delivery will be in 1Q85 to allow the metrics and evaluation research to use them. In 4Q85, after a competitive evaluation of all three IPSEs, a reduced number will proceed, via incremental development, towards second generation capability.

19. The second generation IPSE will contain two major components not found in the first generation IPSE:

a. Database-based tool set (rather than file-based) eg CADES.

b. Support for geographically distributed project teams eg Newcastle Connection.

The second generation IPSE software will run on new hardware; developments in cheaper CPU power, cheaper, high resolution colour graphics, and non keyboard input-output devices, for instance, will facilitate productivity gains due to improved man-machine interaction.

20. The third generation IPSE (or ISF), containing knowledge bases and 'intelligent' tools, requires significant research which must begin now if the 1989 target date for the Information System Factory is to be met.

An Information System Factory will consist of six main subsystems:

a.   specification and prototyping facilities to ensure the completeness and consistency of systems design

b.   a Software Development Environment supporting a whole life cycle methodology

c.   a facility for CAD of VLSI and hardware development

d.   a database or knowledge base of available, reusable software and hardware components

e.   the communication systems, both local and wide area, to facilitate coo-operative development

f.   project management aids.

APPENDIX C: EXPLOITATION

21. The purpose of the exploitation element of the strategy is to see that the software engineering technology available at each stage of the programme is effectively taken up and used by the UK IT industry. In the short term there is an urgent need to promote the more widespread use of the simple tools available today. The scope for immediate improvements in software quality and productivity is large, and the ground would be laid for effective use of the more complex tools of subsequent generations of IPSEs. Three parallel initiatives are needed:

a.   the provision of a well-specified set of compatible tools

b.   the provision of training materials and resources in order to achieve cost-effective use of the tools

c.   capital investment in internal training (including management) and equipment

Organisations thus supported will be required, in return for using the tools, to participate in evaluation and measurement activities.

22. In the longer term continued effort will be needed to ensure that the advances resulting from research are developed and exploited by industry. The long-standing gap between research and production will be addressed directly. It is proposed that, as new techniques are produced by research projects and incorporated into new generations of IPSEs, they will be released for general use. For this purpose a public Software Production Centre will be set up to incorporate and exploit the latest technology. From the first year of the programme, it will provide services and equipment to support:

a.   public use of software engineering tools and IPSE systems

b.   demonstrations of these systems and training for users

c.   a number of collaborative R&D projects and for individual organisations' in-house developments.

23. The programme will also attack the problem of quantification of the improvements in productivity and software quality that can be gained through the use of software engineering. Effort will be devoted to designing measurement methods and applying them in practice. Emphasis on software quality will lead to the growth of software certification. It is proposed to establish a National Quality Certification Centre for the purpose of developing certification techniques and applying them to software products. The Centre will provide facilities for:

a. software certification

b. R&D into methods of measuring various aspects of quality

c. collaborative R&D projects into improving quality, including verification techniques and new approaches to reliability.

24. The activities of these two Centres will stimulate the market for software components and provide for certification of components to national standards. These products will be made available through a Software Components Brokerage scheme, to be run by industry as a commercial venture after financial support from the programme in the early years.

APPENDIX D: DETAILED STRATEGY DOCUMENTS

25. Documents currently available:

a. SE Strategy Overview (Nov 83) (15 pages)

b. SE Strategy (Nov 83) (50 pages)

c. SE Strategy : Reliability and Metrics appendix (50 pages - draft)

d. SE Strategy : Formal Methods appendix (15 pages - initial draft).

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