Architecture of Information Technology

World Bank

Aug, 1990

Technology and Facilities Department
<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
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<tbody>
<tr>
<td>ASE</td>
<td>Computer-Assisted Software Engineering</td>
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<tr>
<td>CITT</td>
<td>International Consultative Committee on Telegraphy and Telephony</td>
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<tr>
<td>D-ROM</td>
<td>Compact Disk Read-Only Memory (optical disk)</td>
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<td>BMS</td>
<td>Data Base Management System</td>
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<td>DCA</td>
<td>Document Content Architecture (IBM)</td>
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<td>EC</td>
<td>Digital Equipment Corporation</td>
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<td>Document Management</td>
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<td>NA</td>
<td>DEC Network Architecture</td>
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<td>DOS</td>
<td>Disk Operating System</td>
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<td>AX</td>
<td>Facsimile transmission technology</td>
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<td>DDI</td>
<td>Fiber Distributed Data Interface</td>
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<td>OSIP</td>
<td>Government Open Systems Interconnection Profile</td>
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<td>UI</td>
<td>Graphic User Interface</td>
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<tr>
<td>VAC</td>
<td>Heating, Ventilation, and Air Conditioning</td>
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<td>IBM</td>
<td>International Business Machines Corporation</td>
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<td>MTPC</td>
<td>Information Management and Technology Policy Committee</td>
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<td>RM</td>
<td>Information Resources Management</td>
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<td>ICS</td>
<td>Information Services Center</td>
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<td>SDN</td>
<td>Integrated Services Digital Network</td>
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<td>ISO</td>
<td>International Standards Organization</td>
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<td>ITA</td>
<td>Information Technology Architecture</td>
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<td>ITAC</td>
<td>Information Technology Advisory Committee</td>
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<td>ITFS</td>
<td>ITF Policy and Strategy Staff</td>
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<td>JILS</td>
<td>Joint Libraries Information System</td>
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<td>LAN</td>
<td>Local Area Network</td>
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<td>MRC</td>
<td>Machine Readable Catalog (A family of communications formats for cataloging data)</td>
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<td>IST</td>
<td>National Institute of Science and Technology (US). Formerly the National Bureau of Standards.</td>
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<td>OCR</td>
<td>Optical Character Recognition</td>
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<td>ODA</td>
<td>Office Document Architecture</td>
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<td>SDIF</td>
<td>Office Document Interchange Format</td>
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<td>OSIRI</td>
<td>Open System Interconnection Reference Model</td>
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<td>OTC</td>
<td>Office Technology Coordinator</td>
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<td>ABX</td>
<td>Private Automatic Branch eXchange</td>
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<td>C</td>
<td>Personal Computer</td>
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<td>OSIX</td>
<td>Portable Operating System Interface X (for Unix origin)</td>
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<td>S/2</td>
<td>Personal System/2 (IBM 2nd generation personal computer)</td>
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<td>PTTS</td>
<td>Post, Telegraph and Telephone Services (public)</td>
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<td>FP</td>
<td>Request For Proposal</td>
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<td>FS</td>
<td>Remote File Server</td>
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<td>SAA</td>
<td>Systems Application Architecture (IBM)</td>
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<td>GML</td>
<td>Standard Generalized Markup Language (ISO)</td>
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<td>SNA</td>
<td>System Network Architecture (IBM)</td>
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<td>SQL</td>
<td>Standard Query Language</td>
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<tr>
<td>SAT</td>
<td>Very Small Aperture Terminal (satellite earth station)</td>
</tr>
<tr>
<td>-Window</td>
<td>Draft ISO standard for the support of windowing systems</td>
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Information Technology Architecture is a framework by which an institution can set forth the way in which it will use Information Technology, defined as technology used in the creation, storage, retrieval, and transmission of information, in the conduct of its business. This paper discusses the current and proposed Information Technology Architecture of the Bank, within a framework of the Bank's present and potential future business needs. Its purpose is to provide an overview of the Information Technology Architecture that has been developed by ITF, in consultation with users, over the past two years.

The objectives and criteria for an Information Technology Architecture for the Bank derive from the Bank's medium-term strategy for information and technology as set forth in the Board paper on Information Management and Technology Strategy (November 1989). While the architecture is not a plan with specific dates and implementation details, it is a framework, with a time horizon of the 1990s. Through a clearly defined and continuously updated set of standards, it provides a framework for decision making by business managers on the acquisition and use of Information Technology.

The Information Technology Architecture for the 1990s, which supplants the 1983 Information Resource Management Strategy, has been articulated around two key objectives: flexibility and cost-effectiveness. In the past decade there has been a rapid increase in the varieties and capabilities of information technology products, and at the same time, recognizing the difficulties of managing such diversity, an industry trend towards common standards. Taking advantage of these trends, the Bank's Information Technology Architecture moves from the previous concept of standard, but vendor specific, products, to the current one which is built around product standards with an emphasis on increasing vendor independence. This allows flexibility and cost-effectiveness in the acquisition of information technology products through competition between vendors and an ability to exploit economies of scale. It allows these principles to be pursued in the use of information technology by the emphasis on common user interfaces, on the smooth evolutionary transition from older to newer technologies and by building on the accumulated experience of Bank staff. Similarly, in the operation and maintenance of information technology, the approach allows the institution to exploit economies of scale and to take advantage of industry-wide standards.

The Architecture thus responds to the Bank's expressed objective of utilizing more effectively its human and information resources, by providing a guiding framework for the acquisition, use and maintenance of information technology in the 1990s.
i. In pursuit of its business objectives, the Bank has always faced the challenge of providing Bank staff with the tools to acquire, analyze, store, and communicate information. Over the years, the Bank has used a variety of technologies and procedures to help it meet this challenge. In recent times, the Bank has increasingly relied on electronic information technologies.

ii. The expanding scale and scope of Bank's use of electronic information technologies calls for an architectural framework within which decisions can be made regarding the cost-effective acquisition and deployment of information technology over the next five to seven years.

iii. The key characteristic of the current Architecture, which distinguishes it from the architecture that was adopted as part of the Information Resource Management Strategy in 1983, is its reliance on standards that are either formulated by independent, (international) standards-setting organizations or are de facto industry standards that have attained a sufficient "non-proprietary" status to be adopted by a standards-setting organization. Such standards are often called "open" standards.

iv. The benefits to the Bank of the increasing ascendancy of non-proprietary, open standards include: (i) cost savings, arising from increased competition in the information technology market place; (ii) a reduction of the technological and market risks inherent in investments in single-vendor, proprietary technologies; and (iii) an increasing emphasis on compatibility between different technologies, (e.g., telephones and personal computers) as well as between technologies from different vendors.

v. For the typical Bank manager, this means that the deployment of information technology should gradually become increasingly transparent and decreasingly disruptive during the 1990s. Although the existence of the Architecture will not eliminate the need for managers to dedicate time and effort to managing information technology, managers will, however, be able to increasingly focus on what business opportunities to address with information technologies and increasingly will be less concerned with the technologies themselves.
1. **Introduction**

1. This paper presents an overview of an Architecture for the Bank's Information Technology in the 1990s which replaces the formal architecture adopted in 1983. It has been developed by ITF, in consultation with users, over the past two years. It reflects changes in the Bank's business requirements and changes in the Bank's information technology options. Annex A to this paper provides a more extended technical discussion of the Architecture. Annexes B - F provide further supporting technical materials.

**The Role of Information Technology Architecture**

2. In pursuit of its business objectives, the Bank has always faced the challenge of providing Bank staff with the tools to acquire, analyze, store, and communicate information. Over the years, the Bank has used a variety of technologies and procedures to help it meet this challenge.

3. In recent times, the Bank has increasingly relied on electronic information technologies. Typically, these have replaced and complemented those previously employed. Personal computers have increasingly displaced dedicated word processors which, in turn, displaced typewriters. Spreadsheet programs have displaced calculators, which displaced compound interest tables and "green sheets". Electronic mail and facsimile have increasingly displaced internal memos and traditional mail services and have complemented telephones. These trends show no signs of abating. On the contrary, the variety of electronic technologies deployed—and their penetration into the work processes of the Bank—is accelerating.

4. The expanding scale and scope of Bank's use of electronic information technologies calls for a framework within which to make decisions regarding the acquisition and deployment of information technology. This framework must help the Bank meet its business needs cost-effectively, as new needs arise and as technologies become available to meet existing needs. It must also reflect the organization and practices of the Bank. The Bank's revised Information Technology Architecture is designed to meet these requirements over the next five to seven years.

5. Until the early 1980s, decisions about the acquisition and allocation of information technology were primarily the concern of a central administrative department. However, at that time, it began to be recognized that highly centralized arrangements for decision-making and provision of information technology were neither practical nor appropriate. Given the rapidly expanding scale and scope of information technology, the problem of assessing the numerous and varied information technology needs of Bank staff had outgrown the capacity of a central information technology authority. And it had become clear that the responsibility for decision-making and managing information technology should rest with the business managers throughout the institution. The rest of the 1980s have seen the consolidation of these realities.
6. In this environment, the responsibilities of the center (since 1986, ITF) are
two-fold. First, to manage those types of information technologies that can be
considered as infrastructure (e.g., the telephone system, the data communications
network, and the large, central computers on which much of the institution's electronic
information is stored). Second, to support decentralized decision-making about
information technology in such a way that technologies selected by business managers
are compatible with the institution's information technology infrastructure, and so
that the "external" costs and benefits associated with information systems deployed by
the individual business units can be effectively managed.\(^1\) In short, the growing
pervasiveness of information technology requires that (i) the Bank adopt an
Architecture as a framework for decentralized decision-making and (ii) Bank managers
understand the nature of this Architecture and their roles and responsibilities in
relation to those of the central information technology department (ITF).

**Architecture and Standards**

7. The key characteristic of the current Architecture, which distinguishes it
from the architecture that was adopted as part of the Information Resource
Management Strategy in 1983, is its reliance on standards that are either formulated
by independent, (international) standards-setting organizations, such as the
International Standards Organization or the UN's International Consultative
Committee on Telegraphy and Telephony, or are de facto industry standards that have
attained a sufficient "non-proprietary" status to be adopted by a standards-setting
organization. Such standards are often called "open" standards.\(^2\)

8. The growing importance of open standards reflects a trend in the
information technology market place, in which the technological impetus has shifted
away from a small number of dominant suppliers towards users and a more competitive
market. This shift, in turn, reflects two other market trends. First, the explosive
growth in the amount of information technology installed and the concomitant growth
in the user community. Second, a rapidly proliferating variety of cost-effective
information technologies and the resultant inability of any single vendor to supply the
complete suite of desired technologies (now and in the future). The growing influence of
the user community and the need for harmonizing a variety of technologies from a
variety of vendors has forced even the formerly dominant systems suppliers to accept
the need for independent arbitration of many technical specifications.

9. The benefits to the Bank of the increasing ascendancy of non-proprietary,
open standards include: (i) cost savings, arising from increased competition in the

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\(^1\) Implementing a shared information system for, say, trade data generates external benefits to business
units throughout the Bank that make use of the data and imposes external costs by requiring specific
communications technologies and/or specific programming skills.

\(^2\) Whereas the 1983 IRM strategy specified proprietary "standard products"; the 1990 IT architecture can
now be characterized by non-proprietary "product standards" (i.e., standards that specific products must
meet to be in compliance).
information technology marketplace; (ii) a reduction of the technological and market
risks inherent in investments in single-vendor, proprietary technologies; and (iii) an
increasing emphasis on compatibility between different technologies, (e.g., telephones
and personal computers) as well as between technologies from different vendors.

10. For the typical Bank manager, this means that the deployment of
information technology will gradually become increasingly transparent and
decreasingly disruptive during the 1990s. Also, for any given level of functionality, it
will mean less "non-productive" staff time must be allocated to learning how to use
information tools and to managing and trouble-shooting information technologies. The
existence of the Architecture will not eliminate the need for managers to dedicate time
and effort to managing information technology. Managers will, however, be able to
increasingly focus on what business opportunities to address with information
technologies and increasingly will be less concerned with the technologies themselves.

11. In due course, the day should eventually arrive when the underlying
technology of information systems will be of no more concern for the typical manager
than the technologies employed to heat and cool the buildings in which they work.
Notably, in some information technology areas—typically those governed by
independent standards-setting bodies—this vision is a reality. For example, it is of no
concern to a manager whether telephone calls to Paris are routed via undersea cable or
satellite, so long as they go through and are clear. Nonetheless, there is still much
progress to be made in many areas of information technologies, and there will remain a
need to provide guidance on the application of information technology to meet business
objectives.

**Background to the Architecture Project**

12. The first explicit statement of the Bank's Information Technology
Architecture was developed in 1983, when the Information Resource Management
(IRM) strategy was issued. This comprehensive set of documents focussed on the
information and information management needs of the Bank's business and the state of
the information technology industry at the beginning of the last decade. While the
IRM concept as such is still valid, the Bank's business, the information technology
market, and the Bank's organization and processes have all undergone substantial
changes. As a result, both the IRM architecture and the strategy it set forth were in
need of revision by the late 1980s.

13. This project was initiated to examine and reformulate the architecture of
the Bank's information technology. A series of working papers was prepared in FY89-90
describing requirements, options, and recommendations in five major areas: (i)
mainframe and personal computing; (ii) document management technologies; (iii)
global communications; and (iv) internal communications. These papers, which have
been reviewed by the Information Technology Advisory Committee (ITAC)\(^3\) include
background material on the status of technology in the Bank and assessments of the
likely availability of new capabilities in the marketplace. They provide the basis for

\(^3\) A Bank wide committee that advises the Director of ITF.
developing an integrated approach to technology architecture guidelines for technology, hardware and software acquisition during the 1990s. The working papers, which are necessarily technical in nature, have been, or are being, issued as ITF Staff papers. Annex A provides a technical integration of these Staff papers.

II. Information Technology Needs of the Bank in the 1990s

Information Technology to Meet the Future Needs of the Bank

14. The Bank's objectives for information and information technology management, as set forth in the Information Management and Technology Strategy paper endorsed by the Board of Directors in November 1989, provide a foundation for the elaboration of the architecture for information technology. The basic functions that the Bank will require of its information technology in the 1990s are to facilitate the free flow of information and increase the ease of use of information systems. To accomplish this, the areas of focus for the deployment of information technology include: (i) enhanced communications, particularly in reliable, transparent, and cost-effective networks; (ii) enhanced access to the information stores that are critical to the Bank as a knowledge-based institution; and (iii) enhanced effectiveness of the institution's human capital.

15. The first key technical requirement is transparent, high-speed, transport of all types of information within the Bank, in order that staff can benefit fully from its information stores. It will also be essential for people and institutions in member countries to have increasing access to those stores. Enabling this flow must be an early goal of information and technology management. In short, the Bank's information transport system must be developed to make physical location an immaterial factor in the conduct of business.

16. The second requirement is to enhance the ease of use of the Bank's information systems. Thus far, information technology, and in particular office technology, has been largely concerned with making computing power widely available to individuals, rather than enabling them to make fully productive use of it. The creation of more powerful and easier-to-use tools for creating documents, for analyzing information, and for communicating ideas has increasingly become the focus of the industry. If the Bank is to meet the challenge of accomplishing more with static

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resources, increasing functionality and ease of use will be required. In particular, the ability to easily communicate with and through office technology and to transparently access the information stores of the Bank and information stores around the world is essential. This process of empowering the individual has only just begun.

17. A third requirement is to enhance interactions within groups, by providing tools for "group work". While it has been appropriate for the Bank to focus on the individual, this approach has not solved the traditional inefficiencies that arise when several people must be involved in a particular project. The current and future information technology of the institution therefore must address the issues of groups and the means to make them function more efficiently. Electronic and voice messaging are emerging as powerful, interactive group tools. Decision support tools hold great potential for enhancing group effectiveness. Other tools are just now emerging as the information technology market focuses more attention on the work group.

18. Figure 1 presents a view of what the structure and functionality of the information technology of the Bank might be in the middle of the 1990s. Central to the functioning of the institution, and thus to the design of the Architecture, are the individual staff members of the Bank, whether they be at Headquarters, at home, in Field Offices, or elsewhere in the field. Each should have available a personal computer—both at and away from the office—to provide full time access to the Bank's information and communication resources. The interface should be capable of being personalized, reflecting the fact that people are different and need to access and use information differently. Beyond this personal interface, the institution would provide technology for common, local business services (such as printing, file sharing, document management, time management, etc.). It would also provide a common access to both text and data stores of the Bank and to a hub for communicating around the world, whether it be to other Bank staff, to governments, financial institutions, or Field Offices.5

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5 Figure 1 is a simplification of an actual physical configuration. The shared computers depicted for data and text may be one or many, depending on specific needs. Similarly, the external network could physically have a number of hubs and a multiplicity of actual connections, again depending on specific cost-effective solutions. Also, the pattern of information technology at Field Offices would follow that shown for Headquarters.
FIGURE 1: The Bank’s Information Technology in the 90s

External Communications Facilities

- Data Systems
- Document Systems

Local Business Services
(Communications, File Management, Printing, etc.)

Headquarters Staff

Staff at Home
Donor Govt.
Member Govt.
Field Office
Academia
Financial Inst.
Staff in Field
III. Information Technology Architecture

General Strategy

19. The basic direction underlying the Architecture is, wherever possible, to take advantage of industry standards and, specifically, to adopt standards based on international standards organizations' specifications.

20. While many of the more important international standards have been promulgated or are in the process of being finalized, finalization of others is still a few years away. Nevertheless, adhering to the standards that have emerged, and a commitment to continue doing so, enhances the Bank's ability to make technologies from different vendors work together effectively and helps reduce the problems associated with introducing new technologies. Their implementation will also help considerably in linking the Bank to borrowers and other external agencies.

21. Given the magnitude of the technical challenge and the necessity to reach agreement on each specification, gaps exist—and will continue to exist—in the coverage of international standards. Accordingly, setting forth a viable architecture will require framing technology choices beyond what these international standards, and sometimes even beyond what de facto industry standards, specify. The challenge is to reflect the human and business needs of the Bank without compromising the viability of the Architecture over time or requiring costly change in the future.

Outline of the Architecture

22. Detailed technical specifications of the Bank's Information Technology Architecture are set forth in the attached annexes. These specifications have been adopted. The following paragraphs highlights their most important features.

23. Shared Computers. In the area of shared computers—the repositories of the Bank's text and data resources (see Figure 1)—the Bank will gradually move to "open" operating systems. This will allow applications written on one vendor's hardware to be transferred to another's (when conditions make this appropriate) with relatively little cost; this has been very difficult in the past. The Bank's three major vendors have all indicated their intentions to comply with this standard.

24. Personal Computers. It is envisioned that the increasing power which is becoming available on the personal computer will be used to enhance the staff's interface with the computer and to perform analytic computations. The electronic storage of information will increasingly shift from personal computers to shared computers, where file management, back-up, and security issues can be more effectively addressed. To accomplish this goal, all personal computers, including portable computers, would have

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6 Specifically, the Bank should adopt the US Government's POSIX specification.
some capability to communicate with the shared computers and other technical services, such as printing and facsimile transmission. In the interest of more effectively utilizing the Bank's human capital, the Architecture calls for the Bank to move to a personal computer user interface which is: (i) graphic—as opposed to the current, character-based interface; (ii) consistent—i.e., actions by the user consistently mean the same thing regardless of the specific application program; (iii) customizable—i.e., adaptable to the individual user's interface preferences; and (iv) capable of simultaneously running multiple application programs, thus allowing the staff to integrate his or her functional tasks in a single environment.\(^7\)

25. **Internal Communications** services refer to the technologies that underlie what are labeled “Local Business Services” in Figure 1. They specify how computers are interlinked, including how personal computers are linked to each other, to mainframes, to the external communications hub, and to the technologies that provide printing, document management, file sharing, etc. The architecture calls for the Bank to adopt the International Standards Organization's model for internal communications.\(^8\)

26. **External Communications** capabilities will attain increasing importance for the Bank in the 1990s as the need to connect overseas field offices, member governments, external sources of knowledge, and staff travelling on mission becomes increasingly critical. The Architecture calls for the Bank to link Headquarters and Field Offices with telecommunications channels capable of supporting simultaneous voice, facsimile, electronic mail, document transfer, and data access (comparable to the circuits which currently link the Paris Office to Headquarters).

27. **Data Management** is essential if the institution is to exploit its store of information on development productively. While this field is perhaps more mature than some others, there is a growing need to make such information more uniformly and easily available. Accordingly, the Architecture calls for the Bank to move to relational data bases and to adopt a standard data query language.\(^9\) The migration of the Bank's current data systems to standard-compatible systems will be an important concern for managers and staff responsible for major data systems. For other staff, greater and easier access to shared data will be the welcome result.

28. **Document (and Text) Management.** Only recently have declining costs of technology brought electronic document management onto the horizon as a practical, cost effective application. Accordingly, the Architecture focuses on moving the Bank's

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\(^7\) This is known as multitasking or windowing.

\(^8\) Specifically, the Bank should adopt the US Government's Open Systems Interconnection Profile (GOSIP).

\(^9\) Specifically, the Bank should adopt the Structured Query Language (SQL) standard. Currently, there are a number of SQL specifications and implementations. It is anticipated that a uniform standard will emerge in the next couple of years.
document production process towards standard electronic document formats, which will make storage and retrieval more efficient when, in due course, the technologies are ready for widespread deployment.

**Implications of the Architecture**

29. The Information Technology Architecture has six major implications. Each is summarized in the following paragraphs.

30. First, the Bank's approach to implementing the Information Technology Architecture is incremental and evolutionary. Accordingly, staff will not experience sudden, large-scale change. The Architecture does not require it, nor does the budget allow it. Instead, there will be gradual progress towards the goal of making information technology an integral part of everyday work and making typical users comfortable with the technology they use. If diverse systems communicate with each other seamlessly (which is not the case today) they will not be noticed. Invisibility or transparency is thus a key part of this future vision and much of the Architecture is focussed on this goal.

31. Second, the goal of transparency notwithstanding, the Bank's large investment in staff information technology skills needs to be maintained and carefully managed. Moreover, the interaction between the information technologies which are made available for staff to perform their business functions and the specific business functions which staff perform needs to be recognized and also managed. Just as the Architecture calls for the development of richer information technology resources and for the evolution of the standards for the interactions between various components of the Bank's information technology, there is a corresponding need to develop a richer set of staff information technology skills and evolve business practices to best exploit the increasing availability of information and information tools. Skills and responsibilities of both higher level and support staff, as well as the accepted procedures for working together, have always been shaped by the available information technologies, (e.g., by the typewriter, the telex machine, the Dictaphone, the filing cabinet, the telephone, the calculator, etc.) Thus, as the available technologies continue to evolve, so too will the profile of skill requirements, responsibilities, and practices. Formal and informal training, career development, job descriptions, and hiring practices all play important parts in managing this evolution.

32. Third, technology should be increasingly focussed on assisting staff member to access the information resources of the institution and the rest of the world, in the form of data, text, or information from other staff member. Accordingly, the Architecture focuses on seamless and transparent "highways" to information stores.

33. Fourth, the Architecture is directed towards making the interface between the user and the full range of information technologies as similar as possible. Electronic mail should appear and function similar to word processing. Word

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10 Specifically, document output will migrate to the International Standards Organization's Office Document Architecture (ODA) standard.
processing should be similar from one work group to another, so that the reassignment of a staff member, from one unit to another is not prejudiced. In general, knowledge acquired in the use of one technology should carry over as much as practically possible to other information tools.

34. Fifth, the Architecture is designed to allow individual flexibility and tailoring of personal computers. Some staff are visually oriented and function best with a graphic interface, others are literal and interact best with keyboards. Still others will (and this is further away) prefer to interact by voice. The Architecture is thus framed to ensure every personal computer looks the same to the “wall” (where the connecting wires go), while being adjustable to the needs of the individual.

35. Finally, the Architecture limits choice. But, it does so, while ensuring that ever increasing functionality is available to address business needs, thus reducing the need for disruptive changes from one technology to another. The Architecture also recognizes that although the individual unit managers are responsible and accountable for decision-making, information technology decisions result in significant benefits and costs to other Bank units. Therefore, the Architecture starts from an institutional perspective, limiting choice only where necessary to harmonize the interests of different Bank units and to achieve the objectives of the the institution as a whole.
Annexes to The Architecture of Information Technology in the World Bank
Annex A

The Architecture of Information Technology in the World Bank—A Technical Discussion
I. Developing an Information Technology Architecture Framework for the Bank

1. This annex presents a technical discussion of the Bank’s revised Information Technology Architecture. It brings together the analyses and recommendations of the background papers which were prepared for each of the following areas of information technology: (i) mainframe and personal computing; (ii) document management technologies; (iii) global communications; and (iv) internal communications.¹

Criteria

2. Reflecting the business needs of the Bank and the nature of the information technology marketplace, the following criteria were developed for formulating the revised Architecture.

- Viability in a Global Environment. The Bank’s global operations make it highly desirable to adopt standards that have been endorsed by the recognized international standards bodies, such as the International Standards Organization (ISO) and the International Consultative Committee for Telegraphy and Telephony (CCITT).

- Robustness. Bank future requirements, and, indeed those of any organization in this time of rapid change, are not very predictable. The architecture must therefore be able to support a wide range of possible future scenarios. Indeed, support for change must be a criterion of primary importance.

- Support for diversity. The Bank needs a strategy that supports a wide variety of systems. If the Bank is unique in its information technology requirements, that uniqueness probably lies in the particular profile of its business operations and their diverse requirements for information technology (IT). Some parts of the Bank operate like an investment bank; some, like a consulting company; and some, like a university, while the Bank as a whole retains the administrative support

requirements of any business. The current technology profiles of the Complexes tend to reflect the differences that would typically be found between such institutions, and presumably these units will continue to need to tailor technology solutions to their particular requirements.

- **Consonance with the Bank's management philosophy.** The Bank has adopted a decentralized decision-making model that extends to many aspects of the adoption and use of technology in support of the Bank's business. The architecture should support this philosophy.

- **Evolvability.** The Bank has a legacy of systems that have been built over the last twenty years, that represent a major investment. An evolutionary strategy to upgrading Bank capabilities is, therefore, desirable. It should allow the Bank to take advantage of new products coming into the marketplace and protect the Bank from dead-end solutions and unnecessary costs.

- **Portability and scalability.** The architecture should support the easy migration of future systems or re-usable code to new hardware environments (portability), including migration from larger to smaller architectures or vice versa (scalability). These features can increase the useful life of Bank systems and allow the Bank to use the most economic hardware configurations available, even though such economies are subject to rapid change. For instance, if a system should increase beyond the capability of a particular class of machines, the Bank should be able to move to a more powerful family or a newly introduced class of machines with few or no changes to its existing code.

- **Technical soundness.** The architecture must be technically feasible and should be proven before being widely implemented in the Bank. The Bank should be progressive in its use of technology, but in general it has no need to experiment with unproven products. On the other hand, long delays in adopting new products may well mean that much of their useful life is over before they are introduced. The timing of technology decisions is very critical in realizing benefits.

- **Feasibility in a cost constrained environment.** Any long-range strategy must anticipate continuing pressure on budgets. The general philosophy reflected in the architecture must, therefore, be that the Bank will evolve its systems within the present level of expenditures. The Bank's technology should be incrementally upgradable. However, as pointed out in the Board paper, the Bank probably spends less on technology than many comparable institutions, and may not be spending enough in some areas. In other cases the priorities for expenditures or the balance between capital outlays and current expenses need to be changed. Moreover, higher levels of spending should certainly be considered when a strong case can be made for the improved effectiveness of the Bank's operations through the use of technology.
3. There are many different patterns in the way in which large organizations handle their IT architectures. At one extreme IT decisions can be very tightly centralized and controlled. In such circumstances, particularly where open and competitive procurements are not required, a company may choose to center its IT on the products of one or of very few vendors. The Bank has already decided that it does not want a high degree of central control over its computing and certain communications expenditures, opting, as have many other organizations, for a greater degree of flexibility and local responsibility for the effective use of technology.

4. In this environment one must, then, consider the other common approach to architecture specification, which is to concentrate on standardizing the interfaces between system components and the structure of the information that must be passed among them. Underlying these standards must also be a model, frequently called a reference model, of how the functions of systems, such as computer-to-computer communications or electronic messaging are to be modularized — in other words, what the components are and what functionality is assigned to each one. To use an analogy to the electrical distribution system, what the IT standards attempt to do is the equivalent of standardizing the wiring, the voltage, the wall plugs, fuses, and the light bulb sockets so that electrical equipment from many different manufacturers can be used and interchanged. What it seeks to avoid is a situation in which one buys a lamp and finds that it requires a special kind of replacement light bulb sold only by its manufacturer. Not only is such an arrangement inconvenient and expensive, but if the manufacturer goes out of business, the lamp is useless.

5. It is, in fact, in these areas that the primary efforts toward development of standards in IT by the ISO and other international standards bodies have been directed. This approach is, therefore, not only in accord with the Bank's management structure, but also with the goal of providing specifications that have international and multi-vendor support. Where international standards are lacking, there are sometimes de facto industry standards, that is, standards that originated with a particular vendor, but which are published and are widely implemented in the industry that can be used. IBM's Systems Network Architecture (SNA) is an example of a de facto standard in use in the Bank. An approach that relies on international standards and other publicly available specifications is referred to, generally, as an open systems architecture.

6. The Bank will adopt an architecture based on open systems standards as its general strategy with the particular standards to be adopted being recommended by ITF and endorsed by ITAC. This practice is in accord with the procedures now used for the approval of the list of standard products supported by the Bank and the ITF strategic initiatives. The advantages, risks, and limitations of the general approach are discussed below, as are the elements of the architecture. A list of specific standards with cross references to the ITF Staff Papers that generated them is contained in Annex B. These
Advantages of the Open Systems Approach

7. The decision to adopt an open systems approach does, in fact, meet the criteria listed above. It adheres to international standards and provides as much flexibility as possible to respond to unforeseen future requirements. It allows local areas in the Bank to satisfy their specific needs while not cutting themselves off from the rest of the Bank. The open systems approach places particular stress on evolvability, allowing individual components to be upgraded or replaced without disturbing other elements of a system configuration. It also allows the Bank maximum flexibility in terms of when it will choose to introduce or upgrade a particular piece of technology.

8. This support for change is one major benefit. In addition, adherence to international standards, not only provides vendor-independence, with its increased flexibility and openness in competitive procurements, but also provides standards that are evolved through a consensus process involving industry organizations, such as the Institute of Electrical and Electronics Engineers (IEEE), vendors, and users. This process can help protect the Bank from incompatible upgrades introduced by particular vendors that may be expensive to implement and may perhaps not be justified by the Bank's business requirements.

Risks, Limitations, and Mitigating Factors

9. There are, however, risks and limitations associated with this approach, as there are with any other. One area of risk is in the availability and adoption of the OSI standards. Some important standards, such as those for network management and electronic mail directories, are still evolving, as are the test suites to certify compliance. However, the standards that cover the most crucial interfaces have been adopted. The US, UK, and other influential governments are already specifying compliance with these standards for new acquisitions. It appears, therefore, that product conformance and development will occur at an accelerating pace in these critical areas. However, it should be stressed that the adoption of the ISO standards is not in itself a complete specification of an architecture. For instance, as will be discussed in more detail below, there is not a single international standard for local area network architectures, but rather several possible standards among which the Bank must make choices.

10. The problem of compatibility among conforming products is being alleviated by the development of more particular, precise, and widely adopted agreements between users, vendors, and government standards organizations about OSI implementations. The ones of most direct importance to the Bank are incorporated into the Government Open Systems Implementations Profile (GOSIP), which has been adopted by the US,
the UK, and other governments. As of August of 1990, new computing and communications equipment purchased by the US Government must adhere to the GOSIP standards. Also, there are programs in the US, the EEC, and Japan for product certification. Conformance testing programs for GOSIP standards, including laboratory accreditation, are scheduled to be in place in the US by the end of 1990, and suites for testing interoperability of certified products are also under development. However, at present, because of the options available in the standards, conformance to OSI standards is not a guarantee of interoperability.

11. Finally, while the risk of a very restricted architecture is that it will not be able to evolve to support changing business functions because it is too rigid, the risk of a completely decentralized approach is that it also will be unable to respond because it is too chaotic and uncoordinated. The adoption of an architecture based on open systems should support the Bank wherever it chooses to place itself between these two extremes, but it does not, in itself, dictate what this balance point will be. If it is not accompanied by continuing efforts at good IT management, it may encourage a level of diversity that would be very costly to the Bank, both in terms of support and in terms of the Bank's ability to carry out its business. For instance, even with an open architecture the Bank must control diversity to some degree to keep its maintenance, training, and support costs at reasonable levels.

12. There are also some limitations to be considered. There are areas in which there are very few international standards, and vendor-specific architectural proposals are largely unavoidable, a primary area of this type being the Bank's mainframe computers and the communications protocols associated with them. Standardization also necessarily lags well behind the introduction of new kinds of functionality, so, as in the past, the Bank will be continually adopting new products for which there are no standards, and for which standardization would be premature.

13. When these two factors are taken together as part of the normal workings of the market, one can be certain that the large computer and communications hardware vendors will continue to provide very real inducements to adopt a uniform suite of their products. These inducements are primarily in the form of integrated solutions that work either only or at their best on that vendor's equipment. The cost of not locking oneself into a single-vendor solution is, thus, occasional loss of functionality or ease of use as well as the difficulties associated with being one's own system integrator. The benefits of not being locked into such a suite are the ability to adopt useful innovation as soon it is proven and to choose the best implementation of a particular type of product, such as a spreadsheet or printer, without having to wait until the product is available from one particular vendor and having to accept the limitations of that vendor's solution. In other words, the Bank can capitalize on the opportunities presented by new technology.

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II. The Architecture Framework for the 1990s

14. Within the Bank there are many levels of administration and cooperation, ranging from the individual through the work group, the division, the department, the complex, and, finally, the Bank as a whole. These different levels have different requirements and different roles to play in the administration of data and documents and in the acquisition of systems. For example, members of a project team may need to have drafts of documents, spread sheets, or models, readily accessible online for all members of the group, but they may also have a strong need to confine access to that circle. Furthermore, most of their output is temporary, and the description and data administration functions can be handled informally by the group, although adequate backup and authorized access in the absence of the staff member who has created particular documents are daily problems in the Bank that require attention in the architecture.

15. Vice presidents, similarly, will want to be able to configure their MIS systems to meet the unique requirements of their complexes, as well as those of the Bank as a whole. However, by contrast, many people will need immediate and simultaneous access to that data, some of which will be critical to their operations. The size, complexity, and criticality of such systems will suggest that they be built and administered by professional information technologists and data administrators and that their physical security is a matter of great concern.

16. Despite the magnitude of these differences, they alone do not dictate a particular hardware/software configuration. Given advances in such areas as miniaturization and communications, a logical design and facilities for administrative control may be realized in many ways. A departmental database can be kept on a mainframe computer in the Computing Technology Center, on a Departmental machine, or even, as a system running on one or more networked micro-computers. The decision depends on many system-linked factors, such as access requirements, system size, number of simultaneous users, frequency of update, and security requirements, as well as the relative implementation costs and maintenance costs of the particular configuration for the life of the system and the distribution of those costs within the Bank.

17. For these reasons the Bank's IT architecture for the 1990s does not generally dictate a particular number or kind of tiers of computing and networking services in the Bank, although a minimum of three is recommended for document management. (See paras 54-55 below). At present computing services are delivered primarily through the Bank's mainframe computers housed in the Computing Technology Center and its desktop personal computers. As the Bank workstations become linked by more powerful and more general purpose networks, the option to use local file servers or mini- or super-microcomputers for functions either largely lacking in the Bank now, such as the automatic back-up of workstation files, or those now handled in other ways can be exercised. This middle level of computing is the one in which the technology is the newest and most volatile, and, in many ways, the most complex. It is also the one with which the Bank and other institutions have the least experience. It will be feeling its way in this area for a number of years to come. At a macro level, then, the architecture
assumes only a mix of workstations and multi-user computers that will evolve in response to technological and business change, and seeks to facilitate that kind of flexibility.

18. In the rest of the sections some of the primary objectives of the architecture are discussed along with the tools and strategies proposed for accomplishing them. They are as follows:

- Establish a global telecommunications network.
- Provide the infrastructure for networking the Bank’s computers.
- Supply graphic user interfaces with cross-product uniformity and context-switching functionality on Bank personal workstations as soon as is feasible.
- Require a very strong business rationale for the introduction of additional shared computers not compatible with existing architectures or for other new tools with a major architectural impact, such as, additional data base management systems or storage and retrieval systems.
- Adopt standards for electronic document formats and electronic mail.
- Provide architecture support for multi-level management of Bank electronic documents and data.
- Adopt a standard query language for Bank data bases.
- Adopt a computer-aided systems engineering (CASE) tool as a standard for the Bank.
- Adopt POSIX compatibility as a standard for computer operating systems.
- Make more effective use of technology acquired through engineering it into the workplace.

Establish a Global Telecommunications Network

19. The analysis contained a forthcoming ITF Staff Paper: Global Telecommunications Technology Architecture focuses on the technical and cost issues in delivering a level of telecommunications service to Bank Field Offices worldwide that is equivalent to those now exist between Bank Headquarters and its Paris Office. The paper envisions a global telecommunications network which would provide robust, 24-hour, multi-channel, two-way facilities and thus support simultaneous voice, facsimile, data and text communications traffic. Subsequent analyses indicate that such capabilities can be provided to all Field Offices for costs that are comparable to the projected cost of continuing with current dial-up facilities.
20. Since the capabilities of the local telecommunications infrastructure vary greatly from country to country—as do institutional factors that influence technological options—the Bank will rely on a hybrid network made up of the following hierarchy of technologies.

- International common carrier-provided, tariffed digital leased services, wherever the local communications infrastructure will support Bank requirements.
- International common carrier-provided analog services using leased lines, where the local infrastructure is inadequate for tariffed digital leased services but adequate for analog services.
- Private Very Small Aperture Terminal (VSAT) earth stations located on Field Office premises, where the infrastructure is poor and where institutional and economic realities so dictate.
- International common carrier analog services with conventional dial-up access where there are, for one reason or another, no alternatives.

21. Steps leading to the implementation of this network have already been taken with the establishment of high capacity leased lines to a number of Field Offices. Implementation planning for Field Offices in Africa is also well underway.

*Provide the Infrastructure for Networking the Bank's Computers and Voice/Data Integration*

22. The heart of the open systems approach, is the International Standards Organization's (ISO) Open Systems Interconnection Reference Model, usually called the OSI model. This model, whose adoption is the most important element in the implementation of the architecture, incorporates the core standards for open systems implementations and specifies their relationships.

23. As shown in Figure 1, the key to the OSI approach is modularization. It looks at all the processes that are involved in having one computing system communicate fully with another one. It separates these processes into seven layers or levels, ranging from the physical characteristics of the wiring to the formats that allow the interchange of documents, data, mail messages, graphics, files, and other media between systems. The model specifies the functions of each layer, the information it can exchange with its neighboring layers or with connecting systems, and how that interchange is to be accomplished. In the figure, these layers are grouped into those providing connectivity and those providing functionality. This distinction will be explored presently.

24. The OSI model, however, is not a single set of standards. In each layer there are multiple standards covering different alternative data communications methods, or, in the case of the applications layer, different applications. Selection of one standard
at, say the Data Link Layer, forces the choice of certain other standards at other levels. These sets of related standards are often called "building blocks."

**Figure 1: The ISO - OSI Reference Model**

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1. Physical
2. Data Link
3. Network
4. Transport
5. Session
6. Presentation
7. Application
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25. Within this model, then, the Bank has decided which building blocks it will support, and the architecture sets forth the specifics in this regard. Just as importantly, it must also insist that the products it purchases correspond cleanly to one or more complete model layers. If products cover only some of the functions in a layer, then they will not interface with the products of other vendors, locking the Bank into a single-vendor solution. By insisting that the software bought must conform to the OSI standards and complete OSI layers, the Bank will lower the cost of connecting systems and promote internal information exchange by decreasing Bank dependence on custom software and special purpose solutions. The evolution of systems will be simpler, and the cost of integrating upgraded hardware and software will be reduced, since as the standards become established new conforming components will communicate with their environments in exactly the same way that their conforming predecessors did. For a summary of the functions of each layer of the OSI model, see Annex F.

26. The specific architecture on internal communications as contained in "ITF Staff Paper No. 2: Internal Communications Architecture" is broken into four categories:

- Voice communications
- Workstation-to-workstation data communications
- Workstation-to-shared-computer data communications
- Shared-computer-to-shared-computer communications.
Voice

27. For voice communications, the Bank's strategy is well underway, as more buildings and offices are converted to the Digital Centrex technology. During the timeframe of this architecture, however, new services will be available and desirable for addition to the Bank's voice system. These services will include voice mail, voice messaging, and ISDN linkages between voice and data services. While voice mail will replace answering machines and will serve as the secondary answering system should the called party be unavailable, voice messaging will permit a manager to leave the same voice message for several people. One example of the last service, linkage between voice and data, could be the ability in All-In-1 to show that there is voice mail waiting, and an indicator light on the telephone set to show that the user has All-In-1 mail waiting. Another would be voice annotation of electronic documents.

Workstation-to-Workstation Data Communications

28. The Bank will follow a long-term strategy of building an institution-wide communications systems comprised of an integrated voice and dial-up data network connected with a high-speed internal data network. The Bank's networks would be based upon the ISO-OSI Reference Model, as specified by the US and UK governments through the GOSIP. Within this standards framework, there are several levels ranging from cabling to user interface, each of which requires specification, as mentioned above.

29. The IT architecture offers the Bank new approaches to avoiding disparate communications networks while retaining flexibility. A communications network may be considered in two parts - connectivity and functionality. The OSI layers associated with the two functions are so designated in Figure 1. It is possible to engineer one uniform connectivity platform solution headquarters-wide, or at least building-wide, while applying different functionality solutions on a case-by-case basis. Typically, connectivity means hardware - the cabling and wire closets, while functionality is provided in software, for example, Banyan Vines, Microsoft's LAN Manager, or NetCommander. The above approach should permit different levels of communications functionality to be implemented, ranging from today's peripheral sharing to much more complete information-sharing systems, while offering a headquarters-wide platform for interconnection.

30. What has been agreed after careful analysis and wide discussion within ITF and with a large number of users, is that a cabling scheme will be implemented that would support both of the two primary connectivity schemes sanctioned by the OSI Reference Model, Ethernet and Token Ring. Such a solution entails little extra cost, since in any cabling scheme, excess wiring is provided within a single cable sheath; however, it allows the Bank to adopt different options in the future, depending on the way in which the market and the Bank's capacity demands develop. Users could be connected to one or the other or, even, both types of networks, depending upon their business and technological needs. The Bank's building standards also specify that new buildings should allow the installation of fiber optic cable to the workstation when that becomes an economically attractive alternative. The architecture calls for running the Fiber Distributed Data Interface (FDDI) protocol on this medium. FDDI will support both Ethernet and Token Ring.
31. For workstation-to-workstation connections, the shielded twisted pair connectivity solution would mean greater flexibility to add functions as needs develop. A work unit could use the connectivity scheme for printer sharing and communications sharing, but without re-tooling, could add advanced Local Area Network communications functions as they are required. In workstation-to-shared-computer communications, there are additional benefits for this connectivity scheme, as discussed below. Thus, a connectivity system would be implemented in the Headquarters campus to support workstation-to-workstation communications consisting of a single cable for data communications between the office and a wire closet. The cable should consist of enough strands of shielded twisted pair wire to support peripheral sharing devices and be able to support either or both Ethernet and Token Ring. The outlet in the office would be capable of being used for any or all of these options, and the wire closets should be built with these options installed. The topology of the connectivity scheme would be star-ring-based for the Token-Ring services and star-based for the Ethernet and peripheral sharing services. The Bank would ensure, however, that it will be possible eventually to install fiber optic cabling to the workstation in the new Main Complex.

32. The Bank and other organizations have learned through experience that each network system must be operated as a micro-facility. That is, adequate support must be provided to each system and to each user. To gain the most effective use of the technology, support to users is essential and there are few ways to gain economies of scale. However, economies may be gained with the careful placement of servers. Essentially, the fewer servers that are deployed, or the more centralized the deployment, the less support is required to maintain this hardware/software system. Thus, to help offset support costs for high-functional local networks, server devices would be supported at the department level rather than at the division level. The costs for the implementation and maintenance of this solution are discussed in the ITF Staff Paper on internal communications architecture.

33. The future of dial-up service is not yet clear. Dial-up access has improved from 300 bits per second (bps) – approximately 30 characters per second – to 2400 bps or 2.4 kilobits per second (Kbps). It is expected that asynchronous communications will continue to improve so that dial-up speeds of 9.6Kbps will be available. The quantum jump, however, will occur when Integrated Services Digital Network (ISDN) or ISDN-like connectivity becomes available. ISDN allows simultaneous digital voice and/or multiple 64Kbps data transmission via a single ISDN port. This greatly enhanced functionality of an ISDN line is a telephone company and PTT-provided capability. It is unlikely that ISDN will be available from PTTs in Bank client countries until very late in the planning horizon for this architecture framework; however, ISDN is available in Japan, a number of European countries, and a large number of US cities, including Washington, DC. It will soon be available within the Headquarters complex, and will, therefore, be a factor in dial-up access to the Bank's shared computers. Experimentation with ISDN-like functionality be performed when practical.

Workstation-to-Shared-Computer Data Communications

34. The design of workstation-to-shared-computer communications depends upon the type of connectivity system installed. The headquarters-wide connectivity system proposed above would permit the same type of access to the shared computers that is
employed today. It would also permit Local Area Network gateways to be added, providing high speed access, and could result in a reduction in the number of connections that a work unit would require to support its staff access to systems such as All-In-1.

35. A problem that has long faced users in multi-vendor computing environments has been the use of proprietary protocols by computing suppliers. IBM has its protocol and DEC and UNISYS, theirs. These communications protocols are different and incompatible. As the Bank has deployed a multi-vendor computing environment, it is forced to deal with these incompatibilities. In such circumstances use of only one protocol results in reduced functionality and performance to users of the other systems, which may or may not be of critical concern depending upon the nature of the use. There has been constant debate within the Bank and in other organizations similarly placed about which of the two dominant systems to provide, since DEC supports Ethernet and IBM supports Token Ring.

36. The shielded pair connectivity solution described above is will allow the flexibility necessary to resolve these problems. To provide wiring to the office to support both protocols will allow the most appropriate one(s) to be employed as user requirements and communications technology develop and change. Thus, the connectivity system outlined above for workstation-to-workstation communications would be extended to provide workstation-to-shared computer communications. This system should have the ability to provide dedicated services to all shared computers from workstations or from work units. The connectivity system should consist of a single cable for data communications that includes sufficient shielded twisted pair strands between the workstation and the wire closets to provide both Ethernet and Token Ring protocols. Between wire closets, the cable should eventually be fiber-optic using the Fiber Distributed Data Interface (FDDI) protocol, but until this is practical, shielded twisted pair is again a reasonable solution. FDDI will support both Ethernet and Token Ring.

37. The user interface between workstations and shared computers needs to be improved so that access can be made more transparent to the user. Regardless of the type and level of connectivity, some customization of the applications will be required to maximize the benefits of this technology, as discussed in paras 56-58.

**Shared-Computer-to-Shared-Computer Data Communications**

38. Much work has already been accomplished in interconnecting the shared computer systems. While each major shared computer has its own internal network protocol (for example, DEC has Dec Network Architecture (DNA), Unisys has Burroughs Network Architecture (BNA), all of the Bank's major vendors support SNA - IBM's System Network Architecture. While SNA is not an ISO standard, it has become a widely-implemented de facto industry standard. Also, SNA is expected to be migrated towards compatibility with the US and European Government GOSIP/OSI standards and thus will conform to the criterion of conformity with international standards. This solves the problem of interconnecting the shared computers, and the architecture therefore adopts the continued implementation of the SNA link.
39. There remain questions of sharing information between the shared computers. While SNA goes some distance towards resolving this question, again, some engineering support will be required within the Bank to provide a reasonable user interface to the workstation so that staff can easily access and extract relevant information regardless of the type of computer on which the information is stored.

**Provide Better and More Uniform Interfaces on Bank Personal Workstations**

40. In many fundamental ways the functionalities of the various personal workstations are converging, and intensive effort that users have often experienced in learning new software packages or upgrades or in moving from one system to another may be much reduced in the future. One of the most crucial areas of this convergence is the user interface. As described in the ITF Staff Paper on Computing Architecture cited above, Graphic User Interfaces (GUI) of the type originated by Xerox corporation, made popular by Macintosh computers, and now becoming available in Microsoft Windows, are clearly going to be predominant in the next generation of workstations. All personal computer interfaces in the near future will have graphic interfaces, but also offer a number of methods for communicating with the system, including touch screens and voice input. The user's work will be made easier, both because the interface will be very similar across applications (staff will move text in a mail message with the same operations used to move it in their word processors) and because the interface will be relatively similar from one computer system to another. They will also allow users to keep several applications open at one time and switch back and forth between them (context-switching) or actually to have more than one application processing simultaneously (multi-tasking). Many Bank staff already find this feature very useful.

41. As an example of this increased uniformity, major personal computer software vendors are making the functionality of their products identical for all the systems they support with interfaces as alike as they can contrive. Files will be completely transportable from one system to another, not only between different workstations, but also between workstations and various levels of shared computers.

42. Although there are no existing international standards, in this area, there are proposals for an international standard windowing interface (X.Windows). The architecture will adopt such a standard if it is issued and, in general, will move as quickly as possible to provide users with more intuitive and consistent workstation interfaces.

43. More generally, in part because of the convergence mentioned above, the architecture deliberately does not require a new personal workstation standard at this time. It is not entirely certain, in fact, how important it will be to choose definitively among the competing personal workstation vendors in the future, although the Bank obviously wants to take advantage of volume discounts and limit its support commitments. In the context of the developments in the industry described above, it is not clear that the selection of a workstation will have the major influence on Bank systems that it has had to date. Nonetheless, it is very important that all Bank users have the benefit of the improved interface technology, which will require a considerable upgrade.
in Bank workstations over the next few years. Since prices are continuing to fall, however, ITF does not anticipate that the Bank will have to spend more for such systems than at present. The architectural recommendation, thus, is to move toward systems providing personal user interface functionality, to watch the competing systems emerging at the present time, and not to commit to a major change in approach until the market directions have become clearer. These recommendations place emphasis where it should be — on the functionality of the product, rather than on the label on the box.

**Improve the Interoperability and Portability of Bank Systems**

44. The architecture is strongly focused on improving the interoperability and portability of Bank systems, that is, first, their ability to be transferred to new or different hardware and, second, the ability of the existing and future systems to be used together productively. The communications standards mentioned above are, of course, a major part of this picture, but many additional steps would also be taken. Among these are the following:

- Adopting compatibility with the Portable Operating System InterfaceX (POSIX) as a standard for computer operating systems;
- Requiring a very strong business rationale for the introduction of additional shared computers not compatible with existing architectures or for other new tools with a major architectural impact, such as, additional data base management systems or storage and retrieval systems;
- Adopting a standard query language for Bank data bases;
- Adopting international standards for applications interfaces and document and those for electronic document formats and electronic mail;
- Adopting a computer-aided systems engineering (CASE) tool as a standard for the Bank to support compatible data descriptions and system development methodologies.

**Adopt POSIX Compatibility as a Standard for Computer Operating Systems**

45. Standardization of component interfaces has now extended to operating systems, in which there are now standards for how such systems should, for instance, communicate with applications packages or peripherals. The Portable Operating System InterfaceX standard (POSIX), has been adopted as part of GOSIP. The "X" indicates its Unix™ operating system origins. POSIX, an American National Standards Institute (ANSI) standard, is not a new operating system, only an interface specification. Because it is part of GOSIP and thus a requirement for US Government procurements, POSIX compatibility will be a feature of most major operating systems.
The Bank can take advantage of its features to improve the portability and scalability of its applications.

Require Strong Business Rationale for the Introduction of Additional Shared Computers not Compatible with Existing Architectures

46. Free movement of information within the Bank requires more than compatible document formats. If for no other reason than the kinds of communications problems cited above, the Bank will approach the introduction of new families of shared computers with considerable caution, and introduce new ones, particular those with proprietary communications protocols not already present in the Bank, only when there is an overwhelming business requirement that justifies the additional burden to the rest of the Bank. Data and document interchange would be simplified if the Bank's shared computing would evolve to a less diverse configuration than it has at present, but the architecture recommendations in ITF Staff Paper 2: Computing Technology Architecture for the Bank in the 1990s do not lay down such a requirement. The number of different database management systems would also be kept to minimum, as would the number of different storage and retrieval packages used for document management. The Bank's systems would evolve toward more formal relational databases.

Adopt a Standard Query Language for Bank Data Bases

47. There are many possible approaches to improving the ability of staff to query databases on a case-by-case basis. One more general solution is the adoption of the Standard Query Language (SQL). SQL is one of the few international standards associated with data base management systems, and is important to the Bank's efforts to improve the usability of its data bases. All Bank data base management systems should have SQL capability.

48. The concept and benefit behind SQL is that the query language for requesting data from a data base should be independent of any particular vendor package. The result is, that multi-system data gathering is much simpler: the user need learn only one query language, not many, to use a range of databases.

49. Beyond that, however, vendor independence also means that independent entrepreneurs can develop packages that translate a variety of user applications to SQL automatically, shielding the user from SQL itself, which is not at all user friendly in its native condition. For instance, there are natural language interfaces and sophisticated graphics interfaces that automatically generate SQL code and operate with a number of database packages. The standard potentially assures the software developers of a broad market drawn from a spectrum of SQL compatible systems and makes their investment more viable. If the Bank insists on SQL compatibility in its data bases, it will considerably simplify the problems in developing user friendly front-ends to Bank data base systems and protect its investment in that effort from obsolescence when the data base management systems are upgraded or changed.

50. Adopting SQL will not solve all access problems, however. One important problem with SQL at present is the lack of uniformity in its implementation. Many vendors who offer a version of SQL do not adhere strictly to the international standard
as yet. Also, the standard has several levels, and conformance to the lowest level does not provide much assistance. The Bank must develop more specific requirements in this area than are contained in the Architecture at present. Finally, the presence of SQL does nothing to help the user find data and use it knowledgeably. In other words, SQL is a useful tool, but it is by no means a complete solution to the problem.

Adopt International Standards for Electronic Document Formats and Electronic Mail

51. The OSI model is not only concerned with the levels of communications that are far removed from the user. In its top or "application layer" it also incorporates standards and proposed standards for such things as the formats for exchanging documents, mail messages, and data files. One important standard that has been recently adopted by the ISO as part of the OSI model, but which is not yet available in the market place, is the Office Document Architecture. This and other standards are discussed in more detail in ITF Staff Paper 3: Document Management Technology Architecture. This standard specifies a format for exchanging office documents from one system to another, even those incorporating images or graphics, while preserving all aspects of formatting and layout. By including provisions for image and graphics, it is more general than the present de facto industry standard, which is IBM's Document Content Architecture. If it develops as expected, ODA would be adopted as a "lingua franca" among the Bank's word processing packages and between those packages and others that also must import and export electronic documents, such as storage and retrieval software. The Standard Generalized Markup Language, a publishing-oriented OSI standard, would also be considered for adoption for manuscripts intended for external publication.

52. Other application layer protocols cover additional areas critical to the Bank, especially electronic mail. Those being adopted include the X.400 standard for the format of messages, which is already being widely implemented, and the X.500 standard for electronic mail directories, which is under development. Until X.500 provides a standard for decentralized mail directories, electronic mail directory management in the Bank will remain centralized. These electronic mail standards are discussed in the ITF Staff Paper on Internal Communications Architecture cited above.

Adopt a Computer-Aided Systems Engineering (CASE) Tool as a Standard for the Bank

53. To promote data compatibility, the Bank will adopt a single Computer Assisted Systems Engineering tool Bankwide. Such tools include, among other things, components for maintaining data dictionaries and encyclopedias. When used in conjunction with uniform procedures for data definition, description, and naming, the data descriptions created in conjunction with strategically important system development efforts in the different Bank complexes can be merged to provide a central data base. This data base would support a number of critical functions, such as data location, and information for detection and reconciliation of conflicting data definitions and unintentional data duplication. Such a Bankwide Data Encyclopedia will be developed.
Provide Architecture Support for Multi-Level Management of Bank Electronic Documents and Data

54. As noted above, however, the effective use of the Bank's electronic document base does have certain implications for the architecture. While electronic documents are efficiently and effectively created on personal workstations, that location does not provide security for them without a great deal of burden on staff to remember to back up documents, and ideally, even, to make duplicate backups that can be stored away from the workstation itself. Stand-alone workstations also limit ease of access by other members of a workgroup and do not accommodate some of the technologies that will come into the workplace in the next decade that support cooperative efforts for document production. These requirements suggest a need for the workstations to be connected to a local file server that can provide automatic document and data backup and which is regularly backed-up itself with backups stored in a secure location away from the server.

55. Finally, documents of permanent value and Bankwide importance need to be professionally described and maintained and be made available to everyone who needs them. Regardless of the hardware ultimately selected, this requirement calls for a third tier of systems to support it, probably managed as a Bankwide service, in order to insure the necessary compatibilities, not only in computing equipment and storage and retrieval software, but also in the way documents are managed and indexed. The maintenance of a high quality data dictionary covering data of Bankwide interest is of similar importance to its location and use. This point is discussed further in para 57 below.

Make More Effective Use of Technology Acquired Through Engineering IT into the Workplace

56. While much of the discussion above has centered on system evolution, an important concern is to ensure that technology in place is used to its potential now and in the future. Certainly one cannot simply deliver a personal computer and some software to a staff member's office and expect it to be used effectively, and for all the expected improvements, that statement will be true in the mid-to-late 1990s. Even to use a PC in stand-alone mode requires not only training in the software, but re-examination of procedures and even business practices. Products, work flow, work assignments, job content, procedures for filing, labeling and backing-up documents, and document formats – all need to be reviewed.

57. As the workstations move away from stand-alone operation, the engineering becomes even more critical. The Bank has, for instance, developed an economist's workstation and some tools to allow economists to download information from Bank databases on shared computers, such as the BESD. Similarly, staff in departments such as Human Resources or Bank staff in the Trading Room have systems tailored to support them. But there are many more Bank users who need this kind of help who have not received it. Task managers, for instance, have had to build many of their own planning tools. Work groups need help in customizing applications available through electronic mail to support their particular needs.
58. Reiterating a point made above, users need interfaces that allow them to communicate with the Bank's multiple computing environments to get exactly what they need without worrying about where the data are coming from or learning multiple DBMS query languages. But building applications that communicate effectively with mainframe computers in a multi-vendor environment is a very technically challenging job and one that the Bank cannot expect end-users to undertake for themselves. If the Bank wishes to exploit its investment, it must provide more small application systems, not just application packages in which small systems might be built and more proactive support for Bank staff in using technology effectively. Training also needs to become more focused on processes, such as best practices in creating and maintaining spreadsheets or using electronic mail, basic principles of effective presentation of information through page layouts or graphic design, or procedures for maintaining files in an electronic environment, rather than on training in the idiosyncrasies of particular packages, although that, too, is often required.

59. Many of the above factors of the architecture are summarized and depicted in Figure 2: Key Elements of the Bank's Open Systems-Based Architecture. The figure shows aspects of the communications and computing architecture and their relationships.
Figure 2: Key Elements of the Bank Open Systems-Based Architecture

1. Personal workstation with OSI and SQL-compliant, multi-media, single-user applications; GUI; POSIX-compliant multi-tasking operating system; OSI-compliant communications package.

2. Network servers/shared computers with individual and shared data; OSI and SQL-compliant, multi-media, multi-user applications; GUI; POSIX-EDM-compliant operating system, and OSI-compliant communications package.

3. X.25/X.75-compliant high bandwidth digital connections to field offices and resident missions; ISDN capabilities, where available.

4. Shared computers with OSI and SQL-compliant multi-user applications; GUI; POSIX-compliant operating system, OSI-compliant communications capabilities.

5. Star-configured local network (Token Ring or Ethernet-compliant on shielded twisted pair or optical fiber)

6. FDDI-compliant fiber-optic back-bone
III. Evolving the Bank's IT to an Open Systems Approach

60. A question closely related to the above goal is the path that the Bank should follow in order to achieve an open systems architecture. The baseline from which the Bank's systems will evolve can be briefly summarized as follows:

- The Institution's external communications are carried out almost entirely by the traditional telephone, telex, and paper mail media. There are dedicated communications lines to Paris where there is a small hub for the electronic mail system, to Jakarta where there are similar facilities plus a small analytical computer linked to headquarters, and to Geneva to the UN International Computing Center. There is an increasing amount of facsimile traffic (over telephone lines) between the Bank and its resident missions and relevant government ministries.

- While the physical plant of the Bank has extensive wiring, the logical networks relate to particular mainframes and the dedicated or dial-up lines necessary to provide users with access to these computers. The Bank has an IBM mainframe and a UNISYS mainframe. These are increasingly being used as data storage and retrieval systems as computing power shifts to workstations. The Institution also has more than 20 DEC VAX computers, most of which are linked via an Ethernet system. Of these, a number are dedicated to the Bank's electronic mail system, which provides messaging and information services around the Bank. The existence of three mainframe architectures, which can communicate only on a limited basis, is due to the history of computing in the Bank and the optimization of particular functions, not to any general strategy for Bank computing.

- Local area networks are accessible by a small fraction of the staff. Most work groups have no network, or they only have devices allowing them to share, on a contention basis, printers and dial-up (messaging) lines.

- Information storage and retrieval is virtually all in paper form. There are specialized electronic data storage and retrieval systems for the joint library (used primarily by specialist intermediaries), the EDs and Legal. PPR maintains the BESD data bank on the IBM mainframe. The OPSMIS also resides on the same mainframe as do systems for external debt and human resources. Transactions data, primarily in FINCOM, are on mainframes. Special training is required to use all these systems, and there is little or no carry-over from one to the other.

- There are personal workstations available to all staff members of the Bank, of which several thousand have dedicated communications links for accessing the IBM or UNISYS mainframes. Most of these
workstations are MS-DOS machines that provide capability to create documents (using word processors designed primarily for stand-alone functionality), to do limited analysis, and to be connected, via dial-up protocols, to electronic mail. There are also about 1000 portable personal computers which provide the same functionality at home or in the field.

61. Equipment and software turnover is relatively rapid, particularly in office technology, and therefore the transition to international standards will occur fairly naturally. Because of the emphasis of the US and other governments on conformity to ISO standards – including the OSI reference model – and POSIX compatibility, conforming products will rapidly become available from all major vendors. The Bank must primarily take care not to lock itself into a proprietary solution incompatible with open systems standards before the OSI standards have been widely implemented. Where OSI standards do exist, as in the case of Ethernet and Token Ring for internal communications, the Bank needs to ensure that it acquires only conforming Ethernet or Token Ring solutions when it installs local area networks. Much of the transition to local area networks will occur in conjunction with the Main Complex rehabilitation, as discussed above. In some areas, the Bank has already made the transformation.

62. The Bank’s large systems present more challenging problems with fewer mechanisms for any Bankwide review of enforcement of any standards adopted. Although the Bank’s version of All-in-1 is X.400 compatible, the vendor should certify the product as soon as official conformance testing is available. However, some of the Bank’s important DBMSs do not have an SQL interface or do not have an SQL interface that conforms to the SQL standards at present.

63. More significantly, mainframe communications at this point are heavily oriented toward specific vendors, as has been inevitable in the past. These protocols are not OSI-compatible; however, major vendors are expected to provide OSI and POSIX compatibility, at least as optional features, in the near future. Exactly how these options will perform relative to the vendor’s proprietary systems remains to be seen. Another factor to take into account, however, is that the Bank’s major multi-user systems have, of course, been built under the assumption that they were communicating only with dumb terminals, not microcomputers, since that has been the case until very recently. They thus make use of protocols that support only a master/slave relationship with the host computer. For instance, the OPSMIS, BESD, and other major systems make use of IBM’s 3270 protocol, while All-in-1 uses VT100.

64. These systems take little advantage of microcomputer capabilities. Bank systems should, therefore, evolve toward peer-to-peer communication among its personal and shared computers and phase out its terminal protocols, not only for OSI compatibility, but also in order to take advantage of the improved interfaces and cheaper processing capabilities of the personal workstations. The shared computers will retain a major role in storing and ensuring the integrity of major transaction files and other large databases accessed by multiple users. For more specific information on transition strategies, see the ITF Staff Papers referenced above and in Annex E, which gives the timeframe for the availability of certain technologies.

65. While the infrastructure migration has been described above, in general it will be necessary to develop a plan for each major Bank system, or family of systems
using similar hardware and software, that will outline a migration strategy. However, it is important to remember that this is a long-range undertaking and that the market, driven by major customers, such as the governments and large corporations that are adopting the open systems approach, will provide many of the tools that will be needed. Suppliers of many products that are now standard in the Bank will move to conform to international standards within the next few years, and many additional conforming products will be available for competitive procurement.

66. As part of the transition process, the Bank also needs to pay adequate attention to maintaining and upgrading the skills of its technology support staff. In an area changing as rapidly as IT, new skills are constantly being required. Also, even if the Bank primarily acquires well tested products from major vendors, as is set forth in the Architecture, it will still need to guarantee their compatibility with other Bank systems and verify vendor claims before installing them in the Bank. In many cases competing solutions will need to be tested before major investments are undertaken. Although testing may be distributed throughout the Bank, resources will still be required to undertake it.

67. In addition, all Bank staff providing information technology services will need training in the specification of open systems and in the use and support of OSI-compliant products. For instance, staff engaged in writing and evaluating RFPs will need to learn how to procure open systems, while technology support staff will need to become knowledgeable about interfacing OSI-compliant products. However, such training is a long term investment that will provide the basis for most system integration activity in the Bank by 1995. Bank applications programmers will also need to learn how to use the standard features in compliant products to produce portable, evolvable, and scalable systems. Because of the involvement of the U.S. Government, however, there is much help available outside the Bank that can be utilized, ranging from model procurement language for RFPs to training courses for applications developers. The Bank must begin to take advantage of these resources.

IV. Conclusion

68. The Bank will adopt an architecture based on open systems standards as a necessary and appropriate guide to its long-term strategy for IT acquisition. The development of institutional architecture standards and their continuous review and evolution is a tool for the strategic management of information technology. While the architecture is not a plan with specific dates and implementation details, it is a framework, with a horizon of the mid-1990s. Within that framework the Bank can select, prototype, and pilot specific solutions that match the Bank's business requirements as they evolve. The architecture offers a range of choice consistent with the decentralized nature of the Institution while ensuring institutional needs are effectively addressed. Most important, it provides a framework within which individual decisions concerning future acquisition and use of information technology in the institution can be guided.
Annex B

A Guide to the the ITA Working Papers
### A GUIDE TO THE INFORMATION TECHNOLOGY ARCHITECTURE REQUIREMENTS

#### Specific Requirements

<table>
<thead>
<tr>
<th>1. Recommended Enhancements to Bank Information Technology</th>
<th>ITF Staff Papers or Working Drafts</th>
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<tr>
<td>1.1. The Bank's communications infrastructure will be upgraded over time and in conjunction with the rehabilitation of the Main Complex.</td>
<td><strong>INTERNAL COMMUNICATIONS</strong> : 139-145; <strong>DATA MANAGEMENT</strong> 3; <strong>DOCUMENT MANAGEMENT</strong>: 113;</td>
</tr>
<tr>
<td>1.1.1. The Bank will install a cost effective local area network connectivity scheme during the Main Complex rehabilitation.</td>
<td><strong>INTERNAL COMMUNICATIONS</strong>: 144</td>
</tr>
<tr>
<td>1.1.1.1. The cabling in the Main Complex between the workstation and the wire closet will consist of two sets of shielded twisted pair. (Note: this is a change in the current engineering standards.)</td>
<td><strong>INTERNAL COMMUNICATIONS</strong>: 143-144</td>
</tr>
<tr>
<td>1.1.1.2. Wire closets in the rehabilitated Main Complex will be outfitted with both Token Ring and Ethernet frames.</td>
<td><strong>INTERNAL COMMUNICATIONS</strong>: 144</td>
</tr>
<tr>
<td>1.1.1.3. The Main Complex rehabilitation will adhere to present Bank engineering standards in making sure that it will be possible to install fiber optic cable to the workstation, when such a move is economically justified.</td>
<td><strong>INTERNAL COMMUNICATIONS</strong>: 147</td>
</tr>
<tr>
<td>1.1.2. The Bank will continue to upgrade the communications links among its mainframe computers.</td>
<td><strong>INTERNAL COMMUNICATIONS</strong>: 157; <strong>DATA MANAGEMENT</strong></td>
</tr>
<tr>
<td>1.1.3. The Bank will experiment with ISDN-like functionality as soon as it is practical to do so.</td>
<td><strong>INTERNAL COMMUNICATIONS</strong>: 148; <strong>GLOBAL COMMUNICATIONS</strong> 5</td>
</tr>
</tbody>
</table>
1.2. The Bank will establish a global telecommunications network which will provide robust, 24-hour, multi-channel, two-way facilities and thus support simultaneous voice, facsimile, data and text communications traffic.

1.2.1. Bank will rely on a hybrid network made up of a hierarchy of technologies:

- International common carrier-provided, tariffed digital leased services, wherever the local communications infrastructure will support Bank requirements.

- International common carrier-provided analog services using leased lines, where the local infrastructure is inadequate for tariffed digital leased services.

- Private Very Small Aperture Terminal (VSAT) earth stations located on Field Office premises, where the infrastructure is poor and where institutional and economic realities so dictate.

- International common carrier analog services with conventional dial-up access where there are no other alternatives.

1.3. The Bank will evolve its personal workstations so that they support graphics interfaces, multitasking, and the operating systems and software packages projected for the 1990s.

1.3.1. Personal workstations will provide a choice of a keyboard, a pointing device, such as a mouse, and/or voice input. It will also have graphics interface, and will enable a "windowing" capability to allow multiple tasks to be performed at the same time.

1.3.2. The Bank will upgrade the workstations of Bank staff heavily involved in document production to support 4th generation word processors at least as soon as such machines come within the Bank's present level of expenditure for minimum standard workstations.
<table>
<thead>
<tr>
<th>1.4. The Bank will give more priority to tailoring systems to the needs of particular classes of users.</th>
<th>COMPUTING TECHNOLOGY: ¶85-86</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.4.1. Access to mainframe computer applications needs to be made easier for users.</td>
<td>DATA MANAGEMENT; COMPUTING TECHNOLOGY: ¶33-34,85-86</td>
</tr>
<tr>
<td>1.4.2. Custom end-user front-ends will be provided for multi-system access.</td>
<td>INTERNAL COMMUNICATIONS: ¶159</td>
</tr>
<tr>
<td>1.5. The Bank will continue on the course of implementing a distributed architecture on the federated system model centered around a repository of information about systems that contain strategic data.</td>
<td>DATA MANAGEMENT</td>
</tr>
<tr>
<td>1.5.1. Improve the quality, consistency and usability of existing data bases.</td>
<td>DATA MANAGEMENT</td>
</tr>
<tr>
<td>1.5.2. Describe strategic data according to Bankwide standards and include them in a Bankwide data encyclopedia to form the nucleus of an eventual repository data base.</td>
<td>DATA MANAGEMENT</td>
</tr>
<tr>
<td>1.5.3. Investigate and acquire distributed data base capabilities that will support the interoperability of existing Bank systems.</td>
<td>DATA MANAGEMENT</td>
</tr>
<tr>
<td>1.5.4. Develop a system to use the CASE tool's data encyclopedia as a quality control aid and data finding system.</td>
<td>DATA MANAGEMENT</td>
</tr>
<tr>
<td>1.5.5. The Bank will give preference to DBMSs that can run efficiently in multiple environments and support information engineering practices.</td>
<td>DATA MANAGEMENT</td>
</tr>
<tr>
<td>1.6. The Bank will implement a three-tiered architecture for document management, i.e. with functions allocated the workstation, the departmental level system, and central document management functions.</td>
<td>DOCUMENT MANAGEMENT: ¶100-105, 113-116</td>
</tr>
<tr>
<td>1.7. The Bank will pay increased attention to identifying and testing software for electronic file cabinet and storage and retrieval applications.</td>
<td>DOCUMENT MANAGEMENT: ¶116</td>
</tr>
<tr>
<td>2. Standard and Technical Specifications</td>
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<td>2.1. The Bank will adopt the OSI as contained in the Government Open Systems Interconnection Protocols (GOSIP) adopted by the United States and the United Kingdom as an umbrella specification. This umbrella includes the following specific standards:</td>
<td>INTERNAL COMMUNICATIONS: ¶138-148</td>
</tr>
<tr>
<td>2.1.1. The Bank's internal communications connectivity scheme will permit operation of any or all of the Ethernet, Token Ring protocols and ISDN (which is becoming an ISO standard. It will also support present Bank solutions to aid in transition.</td>
<td>INTERNAL COMMUNICATIONS: ¶74-78</td>
</tr>
<tr>
<td>2.1.2. The Bank will adopt ISO X.400, which governs the interchange of electronic mail messages, as a compatibility requirement for electronic mail systems in the Bank.</td>
<td>INTERNAL COMMUNICATIONS: ¶151</td>
</tr>
<tr>
<td>2.1.3. The Bank will adopt ISO X.500, the standard governing the exchange of electronic mail directory information when it becomes available.</td>
<td>INTERNAL COMMUNICATIONS: ¶117-121</td>
</tr>
<tr>
<td>2.1.4. The Bank will adopt the ISO Office Document Architecture (ISO 8613 88) as the transfer standard for documents in the Bank when it becomes available. In the interim, it will use IBM's DCA as a standard transfer format.</td>
<td>DOCUMENT MANAGEMENT</td>
</tr>
</tbody>
</table>
2.2. Computer systems will be specified, wherever feasible, based upon a mix of international and de facto industry standards, supplemented, where necessary, by functional specifications for areas not covered by the standards.

2.2.1. The Bank's computer systems will be specified in accordance with the Open Systems Interconnection Model as embodied in the Government Open Systems Protocols (GOSIP), a procurement standard adopted by the US and UK governments.

2.2.2. The Bank will adopt the POSIX-compatibility as specified by National Institute of Science and Technology (formerly the US National Institute of Standards) as a requirement for computer operating systems.

2.2.3. The Bank will adopt X.Windows-compatibility for workstation and shared computer user interfaces. X-Window is a de facto industry standard that is being considered as an ISO standard.

2.2.4. The primary shared-computer architectures will be allowed to evolve in response to business needs, but only in ways which are in accord with the Bank's communications system standards and in ways which improve data access.

2.2.5. New types of systems will not be introduced unless their full costs, including integration and conversion costs, can clearly be justified by the Bank's business requirements.

| 2.3 | The Bank will adopt SQL as specified by the ISO as a standard query language for Bank data bases. |
| 2.4 | The Bank will adopt a standard CASE tool. |
Paragraph references for drafts are not included.


Islev-Petersen, Harold. *Data Management Technology Architecture*.


Lindsay, Thomas. *Global Telecommunications Technology Architecture*. Forthcoming.

Annex C

The Role of the Architecture Framework in IT Acquisition Policy and Governance
The Role of the Architecture Framework in IT Acquisition Policy and Governance

1. Decision-making is decentralized in the Bank and varies by the type of IT being acquired, as shown in Figure 1 (Responsibility for Acquisition Decisions by Type of Technology). Similarly one can see in Figure 2 (Roles and Responsibilities for IT Acquisition Policy and Governance after Adoption of the Architecture), that

Figure 1: Responsibility for Acquisition Decisions by Type of Technology

[Diagram showing decision-making processes and responsibilities based on technology type]
Responsibility for policy and governance varies both by whether planning is short, long, or medium term, and whether the policies and standards that result apply only locally, at the complex level, or Bankwide. It is assumed that policies and standards developed at higher levels carry down to the lower levels, although, in order to make the chart less redundant, they are not listed at each level.

2. From the chart, one can see that the Architecture is envisioned to be the primary acquisition policy directive for long term IT planning with Bankwide applicability. As the planning period shortens, other directives come into play, which should be increasingly in consonance with the architecture as the planning period they cover comes to coincide with the planning period of the architecture. They should in all cases not be moving the Bank in directions that are in conflict with an evolution to open systems.

3. Moving to governance, the Architecture, which is a living document and should be subject to periodic review and update, should be formulated and revised by ITFPS in consultation with the Bank. It is proposed that ITAC would have responsibility for endorsing particular standards with Bankwide application. Enforcement would come primarily through management and technical staff education, management review of IT business and system development plans, the present ITF standard products list, and the IT waiver process. However, the ITF standard products list would become primarily a vehicle for listing products whose quality and OSI compatibility the Bank has endorsed and which are supported by the Bank, in effect, the Bank's system environment profile. CPB, ISD, and IAD would continue their present roles in budgeting, planning, monitoring, procurement, and review and audit. AMS 12 will be revised to incorporate the architecture. It should reference a list of currently recommended standards to be prepared by ITF in consultation with ITAC, which should be periodically reviewed and amended to reflect changes in the technology environment and the Bank's business requirements.
Annex D

Some Assumptions about the Use of Information Technology in the World Bank in 1995
1. Technology planning of any sort requires some assumptions about how the Bank will want to use technology in the mid-1990s. Although the approach taken in the architecture primarily emphasizes flexibility and control over the points of interface, there are some recommendations that are based either on (a) projected requirements for increased capacity or functionality or (b) possible shortcomings in the present technology infrastructure. This Appendix presents some of the assumptions developed and used by the ITFPS Information Technology Architecture Working Group in the course of its deliberations, drawn from briefings, interim reports, and other preliminary documents. The analysis is also based on assessments of how data processing and electronic document creation and storage will be managed in the Bank within the next 10 years.

Some General Observations

2. In this section we deal primarily with the requirements of the Bank that stem from the fact that its products are very information intensive and world-wide in character.

The Bank in the 1990s

3. Some specific hypotheses about the future of the Bank are inherent in much of what follows. The Working Group attempted to make some of them explicit, in particular, the following:

- Administratively decentralized management will continue.
- The Bank will also become more geographically decentralized.
- It will be very important to the Bank to be able to exchange information quickly and efficiently in electronic form with Field Offices, member governments, clients, and project sites.
- The Bank is a knowledge-based and knowledge producing organization. The quality and effectiveness of its work hinge critically on the quality and availability of the information that the staff can access and the efficiency with which they can obtain it.
- The Bank is, of course, a source of funding for development, but it is also a source of information. The Bank will be seeking to enhance its role as an information provider.
The Bank will be willing to fund upgrades to its present technology.

**IT in the Bank Relative to Technological Development**

3. The intent of the requirements analysis exercise was to develop a range of possibilities and then to target our working projections fairly conservatively, extrapolating from trends that are already visible in the Bank. Much of the technology envisioned already exists in the marketplace, but is not necessarily feasible with the Bank's present computing/communications infrastructure nor available at a price the Bank would find acceptable. Implementation in the Bank depends, then, on the evolution of the infrastructure and the continued dramatic decline in prices for information technology, but these conditions seem realistic.

4. Some of the major assumptions underlying the architecture are embodied in Figure 1: *Assumptions About the Evolution of IT in the Bank 1989-1995*. The major points to be made are the following:

* The leading edge of technology will continue to advance rapidly - actually exponentially, not linearly. It would probably be most accurate to think of the figure as a logarithmic scale.
• The Bank, like many other organizations, now has a major investment in equipment, electronic data, and human resources devoted both to personal computer and shared-computer technology. It will, therefore, usually seek to adopt new technology on an evolutionary, non-disruptive basis.

• However, the Bank's adoption of technology cannot always be evolutionary, nor will it be even. Evolutionary adoption will cause the Bank and similar organizations to fall further behind the leading edge of technology. This fact, in itself, is not a problem, where existing technology meets the Bank's business needs and support for that technology continues to be available. Indeed, vendors catering to a business customer base, may also become more conservative in offering non-evolutionary upgrades to products. Ironically, of course, such a strategy leaves them vulnerable to being "leap-frogged" in the market by a vendor offering a product that is so superior that users, such as the Bank, are willing to make a radical change for the improved functionality. We presume this situation will occur from time to time, as will those in which a product generation comes to an end with no truly evolutionary upgrade in sight, or a completely new application is introduced of value to the Bank that requires high-end technology.

• As a result, the technology spread that the architecture must accommodate between low-end and high-end technology use in the Bank will be much greater than it is now by the mid-1990s. However, if the implementation of the architecture is driven by well-documented bank requirements, then it will not necessarily support new communications or computing-intensive applications in advance of a general or critical need for them, but architectural options must definitely allow expansion and upgrade of capabilities as the need arises. Vendor-independent international standards will provide long-term direction and help free us from the limitations and product release schedules of a single vendor.

5. The Bank's relations with its borrowers, co-financiers, and cooperating agencies are projected as becoming more and more important and continuous. Robust telecommunications is, of course, one absolute requirement for these linkages, but another is suitable applications running over the links. Electronic mail and FAX are a first step. Mutual access to data bases as required, and cooperative decision making support tools are a further extension. Also possible are such things as cooperatively built and maintained data bases. For instance, borrowers might enter routine data directly into Bank databases and use such data, with Bank additions and enhancements, in their own planning operations. There are examples of this type of application in industry, but problems of ownership of data and data security would have to be carefully addressed.

6. In many cases it is not even a question of whether the Bank wants to do business this way: it will be required to do so. The Trading Room, for instance, has no choice about its complete dependence on electronic linkages, nor could the Bank decide it was going to do away with FAX machines without alienating many of its clients and associates (not to mention its staff). These technologies have become essential almost overnight. The point of these remarks is that technology is a push-pull operation. Requirements both drive and are driven by technology.
IT and the Knowledge Worker

7. There will be changes in who uses particular technologies as well as in the level and type of use. Initially in the Bank, much direct use of computers was by support staff, for data input or for word processing. Now that everyone in the Bank has access to computing, applications will become more oriented toward the needs of managers and higher-level staff, so that their knowledge-based support requirements will become dominant. The support of work groups engaged in collaborative activities will also become a major goal of information technology in the Bank, while transaction-processing applications become steadily less important as a factor in the Bank's overall requirements for information technology support.

8. Integration. One of the primary requirements for increasing the productive use of computing by knowledge workers is improved integration of all computer-based tools, at least from the users perspective. This integration even extends in many cases the development of critical electronic linkages across institutional boundaries.

9. One thing which characterizes knowledge workers is the variety of activities and associated information sources that they need and use. A higher-level staff member who is fully adapted, so to speak, to computing wants to be able to move easily and seamlessly between electronic mail, word processing, time management tools, and any of a large number of applications, including, for instance

- Spread sheets;
- Outliners;
- Management information and other database systems on the shared computers;
- Personal computer data bases;
- "Desk-top tools," such as telephone directories;
- Mainframe or PC-based modeling tools;
- Printer monitoring programs;
- Graphics programs;
- Desktop publishing packages;
- Presentation packages; or
- Project management software.

In the future, the list will probably grow to include access to external data bases, document data bases, central electronic filing cabinets, voice mail, video conferencing, packages supporting shared authorship of documents, and tools supporting group decision making, as management of knowledge workers becomes flatter. With the
exception of the "groupware," that is the software to support group processes, all the packages named above exist and are in use in the Bank and elsewhere.

10. But there is a limit to how many such functions any particular staff member will want to use, as long as each new function has onerous learning requirements and negotiating the interfaces among the applications, if such interfaces exist at all, is an additional burden. Most of development work projected by vendors over the next few years is aimed at solving this problem. Most of upgrades in the basic technology infrastructure of the Bank recommended are aimed at allowing the Bank to take advantage of these solutions as they become available. In the few cases in which the working papers urge an increase in expenditure in some aspect of technology, it is because these solutions are so important to knowledge-worker productivity that they should be acquired as soon as they are fully tested and workable, even if they are not at that point as inexpensive as the technology the Bank has been buying.

11. Disintermediation. One of the major and continuing effects of automation, which will contribute to changes in the profile of technology use, is a phenomenon usually referred to as "disintermediation." Put simply, automation allows people to perform for themselves tasks that formerly required a specialist. Higher-level staff doing their own document production, managers doing their own querying and manipulation of management information, and direct entry of data into transaction systems by the staff generating the data are three salient examples. There will be many more, such as direct entry of data by borrowers, more creation of graphics and maps by non-specialist support and higher-level staff, text searching and bibliographic database searching, telephone management, and some natural language translation capability. The results may not be of the same quality as those produced by the professional intermediaries, but they will be adequate for many purposes and greatly extend the number of people using the service or technology.

12. By doing so, oddly enough, the disintermediating technology can increase, not decrease, the demand for the services of the specialists it is replacing. Consider, for example, if a crude translation capability for Spanish were available on higher-level staff workstations. Staff might begin to translate Bank documents into Spanish much more frequently. As a result, a staff member who had no need for human Spanish translators before may suddenly need them, although not, perhaps, for exactly the same kind of services the translators previously performed. Perhaps they would now spend more time entering specialized economic vocabulary into the translating system, answering spot queries about things that the machine translator has clearly failed to handle, or polishing rough translations.

13. In highlighting the difficulty of predicting the effects of disintermediation, this scenario also illustrates our previous point about automation not being primarily a productivity tool in the industrial sense. The Bank would have just taken a major step toward adding language to time and place as barriers being broken down by automation, but its expenses would not necessarily have declined, and the routine benefits of this new, and quite abstract, capability would be difficult to assess as a return on investment.
Some More Specific Assumptions

14. The sections that follow gives projections of specific functionality likely to be available and in use in the Bank by 1995.

Enabling User Exploitation of Data Will Become the Primary Concern of Data Management.

15. In the past, the primary emphasis in data management has been in collecting data, using it in transaction processing, or making available in routine, pre-specified report formats. These reports are often printed and distributed in paper. Such applications are inflexible and of relatively little use for such activities as planning or analysis. The management information systems have also been aimed primarily at the needs of the upper levels of management, and have provided line managers and higher-level staff needing management information for projects with limited capabilities. Existing planning support consists primarily of providing a manager with spreadsheet software on a workstation. If he has the time, patience, and inclination to figure out what data might be useful to him, where it is, how extract it, and how to program a spreadsheet to manipulate it, he may be able to do "what if" projections and other useful analyses. Or he may be able to find someone to do all these things for him. Otherwise, the option of doing this kind of analysis is foreclosed to him, potentially creating information "haves" and information "have-nots" even within the Bank.

16. The new emphasis on decentralization and flexibility in the Bank's management style and an increased emphasis on the Bank as an information provider will lead to more exploitation of the Bank's data and a demand for better tools for doing so. Specifically the following is predicted:

- The introduction of decision support systems specifically engineered for managers, including ones that draw on multiple data bases on multiple systems. For instance, one might wish to see the documents associated with a project in conjunction with management information about that project.

- The use of extended modeling capabilities that will be possible through greater computing power in the workstation and the shared computers, better availability of data in electronic form, and artificial intelligence techniques that can extend purely quantitative methods.

- Information network linkages to Bank clients, suppliers, and affiliates in addition to the ones that already exist for electronic fund transfer and other financial functions. Such networks will deliver new services and also entail greater accessibility of some Bank systems to outside agents, including direct input of data by borrowers and querying of certain Bank systems by borrowers, member governments, consultants, cofinancing agencies, and other interested parties.

17. This latter point has several implications. One of the more interesting ones is that "back-office" Bank staff may have much more direct contact with Bank clients.
than they do now. Of course, security is also a major worry. One cannot allow such linkages to compromise Bank operations.

18. Artificial intelligence, which will be built into many new products to support not only modeling, but also enhanced user interaction and increased processing capabilities for error detection and correction. Such expanded capabilities include the enforcement of new kinds of intelligent constraints on database values based on the underlying data models that reflect business practice. Database systems will also become multi-media systems, supporting text, graphics, image, voice and other media, as well as data. New generations of database management systems available by the end of this period will also go beyond the "snapshot" view of the world now provided and allow querying both of past states of the system and of situations as of particular dates, where that differs from current information.


19. The greater part of the Bank's information is in documents, not in data. As the technology to exploit text and other document components electronically is added to its existing ability to create them in this mode, document-related applications will become an increasingly important aspect of the Bank's computing. These trends are already quite apparent in, for instance, the use of electronic mail, which is primarily text oriented, in the heavy use of personal workstations for document creation, and in the exponential growth in the use of electronic mail and FAX.

20. In some ways, however, the future will not be a linear projection of the present trends because the nature of documents themselves is changing. The Bank now has paper documents and the electronic form of paper documents, including documents that are mixtures of text, image, graphics, and spreadsheet output (compound documents). What it will have is true electronic documents: documents that have no paper equivalent - multi-media documents, documents with links to live databases, interactive documents, multi-dimensional documents. In the long run, this revolution may be comparable only to the invention of written language in its effects on how society thinks and communicates. This change will begin to be felt selectively within the Bank in the time period under discussion, both in the documents the Bank produces and in the ones it receives.

21. Another major consideration from the point of view of architectural requirements is the role of image (facsimile) reproduction of documents or parts of documents in electronic document management and use. At present, the easiest method to capture documents in electronic form is to create a bit-mapped facsimile of them or "image," using a scanner. Moreover, image is the only method of capture that can exactly reproduce the appearance of a page that includes anything other than text, such as signatures, letterheads, annotations, photographs, or other inserts, which is required for many document applications. For instance, image technology is the basis of the FAX machines that are in wide use in the Bank.

22. However, at a resolution of 300x300 pixels per inch (the CCITT Group III FAX standard and the resolution supported by laser printers in the Bank), the image of a page of text requires roughly 50 times the number of bytes that the same page of text requires in machine readable characters (electronic mail) format. Furthermore, there are very few workstations in the Bank that have screen resolutions or memory capacity
that is suitable for image display, so the transmission can only be printed, not exploited electronically. At the present time, Bank staff are not sending very much image data over its internal data communications networks, although some images are sent to printers from graphics-equipped workstations, but the popularity of FAX suggests that that situation could change rather quickly. Image will become an important feature in Bank information management over the next decade.

Effective Use of Workstations Will Continue to Expand the Users' Power over Information.

23. There is now roughly a one-to-one correspondence between the number of Bank staff and the number of personal workstations in the Bank. The first step has, therefore, been taken in providing Bank staff universal access to the functionality of an intelligent workstation. The capabilities of these devices fall into three categories: (1) what they can provide users as an interface, (2) what they provide in communications, and (3) what computing power they can support as stand-alone devices. These three aspects together define the kind of access a Bank staff member will have to the information resources of the Bank and the world and the degree to which they can create and manipulate information.

24. The move from dumb terminals to personal computers is very important, although the full benefits of this move have not yet been realized. In part, many users do not exploit the microcomputer capabilities because the Bank has not yet developed applications, such as decision support software, that can help them exploit the Bank's information resources without major effort. However, many problems arise from a lag in the industry. Until software developers for shared-computer applications can assume that access to the shared computers is through personal computers, they will continue to write shared-computer applications, such as database systems and electronic mail, for the least-common-denominator, which is the dumb terminal. This practice results in lower functionality in the applications and also in an unnecessary burden on the shared computers for screen-painting and other activities that would be eliminated if a better division-of-labor existed between the shared computers and the personal workstations. The Bank is now in a position to take advantage of improved applications as they become available.

25. In the area of computer interfaces, it appears that the technology being offered by various vendors is converging in substance, although no international standards are expected in this area in the immediate future. The interface technology that will be used was first developed by Xerox, but exploited by Apple for its Macintosh interface. Now, all vendors will offer windowing; pull-down menus; multiple entry technologies, including keyboard, pointing device, touch, and, eventually, voice; and multi-tasking. Further, they are making efforts to ensure, as is now the case with the Macintoshes, that applications packages will use a standard set of commands located on standard menus for those functions, such as open/close, save, print, cut, paste, or copy.

26. The Bank will adopt interfaces of this type, and, furthermore, staff would be able to customize them so that they can utilize whatever devices they feel comfortable with. In the Staff Working Paper No 1 on computing architecture, this concept is called a "personal user interface." The Bank will also want to build some custom interface applications on top of this technology to provide transparent access to Bank information
and computing facilities. With this enhanced interface technology, changing from one workstation vendor or workstation operating system to another should be much less disruptive to users than it is at present, particularly if the Bank selects personal computer software that runs under many major vendor interfaces. This type of interface allows users to learn packages much more freely and rapidly and therefore permits the staff to use a wider variety of functionality. Finally, most staff have already made the initial high investment of time and energy typically associated with learning the first word processor or the first spreadsheet. Changing packages usually requires much less effort. The prospects are good, therefore, for increased flexibility in the choice of workstation technology without major disruption to users.

27. The other major source of concern, however, from a technical perspective, is the communications capabilities of workstations. Workstations were first introduced with no communications capabilities, then with the capability of talking with other workstations by the same vendor over proprietary networks. Now, due to the requirements of the business marketplace, most major workstation products can be connected to the major standard communications networking solutions, such as token ring and ethernet, either by vendor communications products or by third parties.

28. New workstations coming to the market will generally have to be offered, even initially, with some general communications compatibility if they expect to be adopted by businesses. Again, communications compatibility will be less of a discriminator in the workstation market in the future than it has been in the past, although, vendors will, no doubt, continue to offer functionality that can be carried out only by a cluster of their own workstations, as opposed to a heterogeneous grouping. Facilitating collaborative work or distributed processing with the vendor's shared computers, for instance, will be types of functionality that vendors stress in order to gain competitive advantage for uniform use of their products.

29. Actual workstation performance will continue to increase exponentially. Workstations of the mid-1990s will deliver 30 times the power per dollar of today's workstations. To put the pace of change in perspective, consider that the IBM PC was only just coming to market six years ago, and that their initial configuration was useful for only a year or two before they had to be significantly upgraded in order to run the greatly improved business software products that were being introduced. Much of the extra power of the 1990s will go into supporting such features as multi-tasking, natural language capabilities, voice recognition, artificial intelligence, and other computing-intensive features that will be incorporated into the software applications the Bank buys in the mid-1990s.

Shared Computers Will Increasingly Become a Transparent Utility.

30. Many of the distinctions one now makes among computers are disappearing or becoming dysfunctional, but it appears that the distinction between personal workstations and shared computers is one that should be retained. This distinction has little to do with speed or physical size, but it does have a great deal to do with the facilities provided by the operating system and the data-transfer rates required from storage devices, both of which need to be considerably enhanced for shared machines over the capabilities required for personal computers. However, even personal workstation operating systems will need more capabilities than today's PCs in order to manage such features as automatic update of workstation databases from shared-computer stores and
the division of computing and data storage functions between personal and shared computers.

31. In general, the location and nature of computing power and of data stores will be of less direct concern to users than they are now. The Bank is already working to enhance particular applications so that it can access multiple computers and databases without the user having to go through multiple logon procedures or deal with multiple database query languages. This trend will be extended so that the physical aspects of computing will become of little immediate concern to users. However, this physical transparency should not be confused with lack of concern over responsibility for creation, maintenance, integrity, and access control over information which will, of course, remain important.

*Communications Will Be the Critical Limiting and Enabling Element.*

32. The backbone of all this activity will be the Bank's ability to communicate electronically both internally and externally. These channels must transmit voice, data, compound documents, electronic mail, FAX, and eventually voice mail and other new media reliably and at a speed that is appropriate to the application. Enhanced communications will not necessarily speed up the political processes associated with loan appraisal and negotiation, but it will allow much more continuous interaction with the client, which should result in better quality project work being delivered more quickly. Better information channels will also allow more direct information access by clients and new kinds of information-based services.

33. In addition, it will enhance information sharing among specialists in similar disciplines, both among staff in the Bank and between staff and external researchers and enhance the collaborative work of project teams. For instance, it will be possible for two people to view and manipulate a document on their workstation while discussing it on the phone with both the data and the voice transmission being carried simultaneously over the same phone line. Even now it is technically possible at a reasonable cost, making allowances for the time-difference problems, to communicate as well with a field office in Africa as easily as with someone across the street. The Bank is moving to implement such a capability as rapidly as possible.