CONCLUSIONS AND RECOMMENDATIONS

This paper evaluated four alternative weighted estimators (the operational, Hanuschak-Keough strata mean, Hanuschak-Keough strata median, and the modified operational) of the peak number of hired workers and compared them to the current open estimator approach. These evaluations were made at both the labor region and state level. When considering only the estimates and their corresponding CV's, it was evident that the open estimate was biased downward, while at the same time having an increased CV. This indicated that there was a need for a "better" estimator with a smaller CV.

The analyses indicated that, for the most part, insignificant differences existed between the open estimator and any of the four alternative weighted estimators. However, significant differences were also found. The Delta and Southern Plains regions were both significantly different for all four comparisons. Further review of these two regions indicated that one state within the region was primarily responsible for the significant difference. And, in reviewing that state, one (or several) tracts accounted for a substantial percentage of the estimation difference. This indicated that one (or several) tracts within a state could make a region (or state) significantly different.

When there was no significant difference between the alternative and the open estimate, any of the weighted estimators could be considered as a viable selection. Each of the alternative weighted estimators has a smaller CV than the open estimator. But the H-K median estimator also has a strong upward bias, which greatly overestimates the peak number of hired workers. This upward bias negates the H-K median as an adequate alternative to the open estimator. When selecting between the remaining weighted estimators, significant differences were considered. Of the three remaining alternative weighted estimators, more research is recommended on the Hanuschak-Keough strata mean. While the original prognosis on the H-K mean was positive, this is the first study done utilizing this estimator and more positive results are needed before a conclusion can be reached. The operational estimator is a tried and proven estimator. It had a smaller CV than the open estimator and also improved upon the downward bias of the open estimator. But the recommended alternative is the modified weighted. This estimator achieved the accuracy levels of the operational estimate, while also eliminating the JAS screening for farmers in the more densely populated segments, and thus reduced the overall survey cost. More research is also recommended on a combined estimator based on the modified weighted estimator and the H-K mean. This new combined estimator would merge the strong points of both estimators. It would reduce the screening requirements for potential farm operators within residential areas while, at the same time, lessening the effect of any potential outliers.

COMPOSITE ESTIMATION FOR MULTIPLE STRATIFIED DESIGNS FROM A SINGLE LIST FRAME

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Abstract

The National Agricultural Statistics Service (NASS) uses stratified list frame sample designs for almost all surveys it conducts. The frame is stratified based on control data obtained from previous surveys or other sources. The County Estimates Survey uses multiple stratified designs, each based on a single control variable for each major item of interest. Currently, these data are summarized in a non-probability fashion. A composite approach for post-stratified data is proposed in this paper for summarizing County Estimates data in a probability fashion. This could strengthen the State, district, and county level estimates provided by the County Estimates Survey. A State level composite of direct expansion estimates for total hogs from eight original commodity designs in the 1991 Ohio survey provided a CV of 5.7. A composite of the eight post-stratified estimates produced a CV of 2.3.

Introduction

The National Agricultural Statistics Service (NASS) conducts many surveys covering multiple items. Most of these surveys employ stratified list frame sample designs. The List Sampling Frame contains names, addresses, and control data obtained from previous surveys or other sources for all known farming operations in each State. The control data are used as stratification variables for the different surveys conducted by NASS.

The Quarterly Agricultural Survey (QAS) is a multiple-frame probability survey that covers multiple crop acreage, stored grain, and hog items. The list frame is stratified based on a priority scheme involving cropland, grain storage capacity, and total hog control data. A single design is developed to cover all items of interest. An area frame component accounts for the incompleteness of the list frame and ensures survey coverage for the entire farm population.

Alternatively, the County Estimates Survey is a large non-probability survey conducted in each State designed to provide estimates of crop acreage, crop yield, crop production, and livestock inventory in each county. The survey uses multiple stratified list frame designs, each based on a single control variable for each major item of interest. This design is intended to ensure adequate coverage from the list frame for all commodities of interest.

There are three basic areas of concern with the County Estimates Survey. The first is that the response rate is typically 30% or less, so nonresponse adjustments are problematic. The second is that the County Estimates Survey only covers the list frame population, which typically contains about 60% of the actual farms in a State and about 80% of the production. The third concern is that the data are currently summarized without regard to the probability of selection. If the data were summarized in a probability fashion, then NASS could possibly use these data in helping to set official USDA State level estimates.

Currently, official USDA estimates are based primarily on estimates from the QAS. If the list frame domain of both the County Estimates Survey and the QAS were the same, then the two independent estimates could be composited and provide improved State estimates for the list domain. Improved district and county level survey estimates, including variance estimates, would benefit the published series of county estimates which are continually coming under scrutiny.

A composite approach for post-stratified data is proposed in this paper for summarizing the County Estimates Survey in a probability fashion. This could strengthen the State, district, and county level estimates provided by the County Estimates survey. Analysis of the 1991 Ohio County Estimates survey data investigates the effect of this approach on State level estimates.

The County Estimates Program

Each NASS State Statistical Office publishes annual county estimates for most major agricultural commodities. Current year data are collected using primarily a mail survey in the fall of the year with some selected telephone follow-up. In addition to providing county estimates, the data are used to update the control data on the list frame in order to provide for efficient stratified sampling for all other NASS surveys. State sample sizes are dependent on the number of farms in the State, but typically range from 15,000 to 20,000 with usable record counts around 200 for major items in major counties. However, for minor crops in minor counties, sample sizes are frequently less than 10.

A key feature of the current system is the sample design which involves selecting sampling units from multiple stratified designs. For instance, there may be specific designs stratified on corn, wheat, soybeans, barley, oats, hogs, cattle, sheep, and total cropland. Typically, States will use ten or more separate designs for their survey. Individual population units on the list sampling frame would likely be included in multiple designs. The goal of this approach is to provide adequate coverage of each agricultural item of interest. This is relatively easy for major crops in a State since a sample design including all known operations with cropland would represent most major crops adequately. However, in order to provide adequate representation for rare crop and livestock items, separate stratified sample designs are developed for each agricultural commodity as needed.

The sample design strata for each commodity frame are based on the positive control data for that particular item. Table 1 illustrates the sample design that might be developed for barley in a particular State, covering all known operations that have positive control data for barley. The sample design would only include strata 10 - 40. Stratum 99 contains all population units that do not have a positive control value for barley, and so is not sampled specifically for barley.

Table 1: An Example Stratified Design for Barley

Stratum	Population Count	Boundary (acres)
99	36,000	0
10	2,500	1 - 49
20	1,000	50 - 99
30	400	100 - 299
40	100	300+
Total	40,000	

A single sample unit may be selected from multiple commodity designs. The system identifies which records are duplicated in multiple samples so that only one questionnaire is sent to each sampled unit. The same questionnaire, containing all items of interest, is used regardless of the commodity design (barley, corn, hogs, etc.) from which the record was selected.

For estimation, all survey records from all commodity designs are post-stratified together to the design strata for the commodity of interest. Direct expansion estimates are calculated based on usable sample counts within each post-stratum, not on the original sampling weight. Various ratio estimates, such as using the ratio to previous year, are also created. While this approach makes full use of the available data, the unknown quality of these non-probability survey estimates is a concern to NASS.

Alternative Post-Stratification and Composite Estimation Approach

The alternative approach investigated in this study post-stratifies the survey data from each commodity design separately to districts within the design strata employed when sampling for the commodity of interest. For example, to estimate total hogs from the soybean sample, sample records are post-stratified to cells representing districts within the hog design strata. The district refers to a group of geographically contiguous counties within a state with similar climates and agricultural practices. There are usually five to ten counties in a district and nine districts in a State. The data are post-stratified to the district level rather than to the county level to help ensure adequate sample counts in each post-stratum. Post-stratification to the district level will help provide some added control for county estimates. If only State estimates were desired and data were similar across districts, post-stratification to the State level might be satisfactory. Some commodities are very localized, and the sample may be very sparse in certain districts, so a district post-stratification would frequently be advantageous.

The post-stratified estimate of a commodity total for a particular district (d) and stratum (h) from an original design f is expressed as follows.

$$\hat{t}_{fhd} = N_{hd}(\hat{Y}_{fhd}/\hat{N}_{fhd})$$

where:

N_{hd} = known population count in post-stratum hd

$\hat{Y}_{fhd}$ = direct expansion estimate of commodity total within post stratum hd from original design f

$\hat{N}_{fhd}$ = direct expansion estimate of population count within post-stratum hd from original design f.

A key component of this estimator is the population count for each post-stratum. This value is available from the List Sampling Frame in each NASS State Statistical Office. These estimates are then summed over the strata and over the districts to provide State level estimates for each original commodity design (f) as follows.

$$\hat{t}_f = \sum_d \sum_h \hat{t}_{fhd}$$

The composite State level estimate using all the original commodity designs is expressed as:

$$t = \sum_f \lambda_f \hat{t}_f \Big/ \sum_f \lambda_f$$

Where λ_f is the inverse of the estimated variance of $\hat{t}_f$.

Data

The proposed estimator was applied to data from the 1991 Ohio County Estimates Survey. Unfortunately, the survey data file did not indicate from which design(s) each record was originally selected. Approximately 30,000 records were mailed, with 11,178 records returned with usable data. These 11,178 records were stratified according to the original sample designs, and samples were selected for analysis with sampling rates similar to those actually used.

Table 2 presents the sample design stratified based on soybean planted acreage. Other designs included in the study were for corn, hay, oats, wheat, cattle, hogs, and sheep, and are similar in nature. The "Other" stratum contains all records in the population that do not have a soybean control value. This stratum was not sampled originally for soybeans, but is sampled for this study so all commodity designs cover the same population. The sample sizes for each design should provide reliable State level estimates for the commodities of interest, but may not provide reliable county estimates. The sampling weights used for estimation are based on the population and analysis sample size, even though the sampling was actually conducted from the 11,178 records available. For example, a sampling weight of 5080/684 is assigned to units in stratum 1 from the soybean design shown in Table 2. Consequently, the direct expansion and post-stratified estimates utilize pseudo design-based weights.

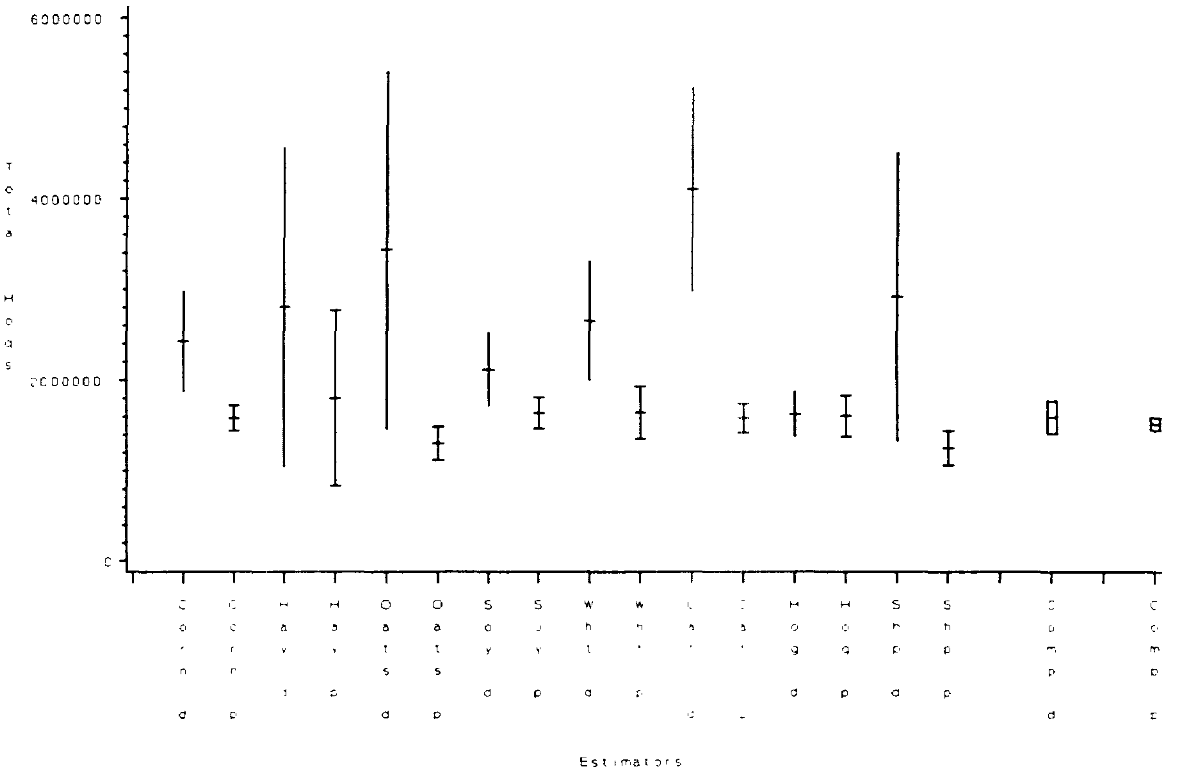
Table 2: Soybean Stratified Design, Ohio 1991

Stratum	Stratum Boundary	Population	Records Available	Analysis Sample Size
99	Other	32708	5162	135
1	01 - 24	5080	1287	684
3	25 - 99	10665	2379	683
5	100 - 249	6142	1424	587
6	250 - 499	2602	658	448
7	500 - 999	777	214	214
8	100 +	121	54	54
Total		**58095**	**11178**	**2805**

Results

Illustration 1 presents State level estimates of total hogs and the associated 95% confidence intervals for the direct expansion (d) estimates and for the post-stratified (p) estimates. Each of the eight original commodity designs (corn, hay, oats, soy = soybeans, wht=wheat, catl=cattle, hogs, and shp=sheep) were included in the study. The composite estimates over both groups (comp d and comp p) are also indicated. The

Illustration 1: Hog Estimates and Confidence Intervals



composite weights are inversely proportional to the estimated variances. A Taylor's Series approximation was used to estimate the variances of the post-stratified estimates. The individual variances were treated as constants when estimating the variances of the two composites.

The illustration shows the pseudo design-based direct expansion estimates have large variances and tend to be biased upwards compared to the post-stratified estimates, which are relatively consistent. This bias is due to an overrepresentation of large agricultural operations among the 11,178 records which were sampled for this analysis. Specifically large hog operations contributed to the biases shown in Illustration 1. The direct expansion from the hog design is not affected by this overrepresentation since the hog sample is stratified by hog control data. Although this is an artificial data problem unique to this data set, the robustness of the post-stratification approach is apparent.

The confidence intervals for the post-stratified estimates of hogs are much smaller than for the direct expansions. The largest reduction is from the original oats design where the confidence interval for the post-stratified estimate is about 10% as large as the direct expansion confidence interval. The resulting approximate confidence interval for the composite of the post-stratified estimates is about 40% as large as for the composite of the direct expansion estimates. The estimated CV of the post-stratification composite is 2.3 compared to an estimated CV of 5.7 for the direct expansion composite.

Discussion and Conclusions

NASS is interested in applying composite estimation to data collected from the County Estimates Survey to improve State, district, and county level estimates. State level estimates for the list frame domain could possibly be used in conjunction with list frame estimates from the probability QAS. This would strengthen the USDA official estimates of various commodities and make full use of the County Estimates data base.

Initial analysis presented in this paper indicates that a State level composite of post-stratified estimates from multiple stratified designs would provide more reliable estimates than a composite of direct expansion estimates. The post-stratification approach exhibited robust characteristics and may also help address nonresponse bias due to the large nonresponse problem in the County Estimates Survey. The variance approximation of the composite estimate needs to be further evaluated.

This composite estimation approach at the district level should also be evaluated. Reliable district estimates benefit the county estimation process since county values must add to the district. The variance approximation of the composite at the district level, which is based on a much smaller data set, also needs to be closely evaluated.

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DISTRIBUTED DATABASE SYSTEM: 3 CRITICAL ELEMENTS

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KEY WORDS: Distributed, database, rightsizing, strategy, technology, implementation, re-engineering

Introduction

In the early information age in the 1960s, the U.S. government, scientists and corporations started to develop systems to reduce the mounting labor effort in the printing paradigm. It was a challenge to allow people access to those systems in an on-line environment. This early information experimentation demonstrated the many centralized data processing concepts in the manufacturing, airline, banking, and census industries. In the 1980s, the data entry mechanism became more affordable. The mass reproduction of systems and data flourished. Voluminous databases and their presentations established the foundation of today's proliferated information base. In the future, the quality, cost, and efficiency of the information and users' perceptions will be improved continuously.

Mainframes have traditionally provided the most effective and controlled utilization of information technology. With the introduction of PCs and workstations, information started to move from the centralized mainframe to local computers. End users are seeking more control and autonomy over their data. The replication of data and the parallel processing on various platforms involve risks of losing security, lack of data integrity and increasing problems with synchronization. MIS Departments face the challenge of implementing distributed database systems in a heterogeneous computing environment. No longer, is it sufficient for them to manage data; management and staff experts demand meaningful information. They will have to develop systems to turn data into useful information. The current environment, where data is incarnated by application systems, will have to end. To meet this demand, computer professionals must work cooperatively with end users. Executives need to empower computer professionals to produce quality systems in a much shorter time frame.

A Transition Plan is needed to ensure a smooth migration from the existing information system to the distributed environment which is currently required. The strategy is to assess the maturity level of the current information processing. The future system shall be clearly defined through business process re-engineering. The strategy should integrate desired business processes, data, implementations, operations, and advanced technology.

The National Agricultural Statistical Services (NASS) is the statistical agency in the U. S. Department of Agriculture. NASS conducts agricultural statistical programs through 45 State Statistical Offices (SSO). The agency has implemented Local Area Networks (LAN) in each SSO, and most recently in its headquarters in Washington D.C. Statisticians, mathematicians and computer specialists in all NASS offices have access to a full range of computer resources from a desktop PC to a large mainframe through LAN's. NASS has long been an advocate of advanced Data Base Management System technology and it continues to explore the most efficient mechanisms to distribute the survey and estimation processing over both the LAN and the wide area network. This paper discusses three critical components of an effective and efficient distributed database system: strategy, technology and implementation, from an operational point of view.

Strategy

The first critical component of an efficient and effective distributed database system is **strategy**. Strategy does not rationalize the benefits or disadvantages of the distributed database system; neither does it address methodologies for utilizing resources, evaluating a specific technology, or selecting a suitable information system to be distributed. All these rationalizations and methodologies do not provide us a distributed database system. A strategy is needed for executives to make decisions. The direction of the distributed database system is a matter of organizational policy. The policy sets boundaries and rules, and the strategy dictates the decision of what has to be done, how, when, where and by whom.

We need to understand the current status of the information system and the involved processes. By developing a new vision of the desired business processes, the necessary actions can be defined. For a distributed database system, software quality becomes more critical. We need to assess the maturity level of the system, and identify risks involved in situations where the business stays as usual and where changes are made. The software system's quality is relative to its level of maturity. The higher the maturity level, the fewer risks the system anticipates.

The Software Engineering Institute (SEI) Process-Maturity Framework Model is useful in depicting the need of a quality distributed database system. SEI, founded by DoD, promotes quality software processes as its primary mission. The empirical model has five maturity levels, Initial, Repeatable, Defined, Managed, and Optimized. The following describes each maturity level, its characteristics, and the key improvement area for the SEI model.

Initial - An ad hoc system is developed as requested. End users rarely involve in the development process. There is no business plan and neither a development plan. People are the key to the success of the system.

Repeatable - A proprietary distributed database system is developed for a specific need. It faces major risks when requirements change. The system quality presents little risks as long as it is within the pre-determined plan and configuration.

Defined - Business plan specifies business processes and data models. A quality distributed database system is developed according to the plan, which uses open standards and advanced technology. Training and reviews are success factors for this level. Computer professionals and end users are given incentives and take great pride in implementing the system.

Managed - A measurable and controlled distributed database system is developed when the development plan and system processes can be measured quantitatively. The system quality is enhanced with the strong commitment from management.

Optimized - An effective and efficient distributed database system is developed and continuous quality review is conducted. The automated process improves human productivity. System quality is achieved through the Defect Prevention Process (DPP). The organization's performance is judged by meeting the planned objectives.

The process of assessing system maturity level reasonably represents the evolutionary improvement of the software development from the past. The model provides guidelines for improving system quality. The maturity level assessment helps to define actions needed for enhancing the quality of the distributed database system.

A system development and improvement plan is required to accommodate actions which need to be prioritized and assigned appropriate resources. Furthermore, executives need to commit resources to execute the plan. A measurement process is mandatory to monitor and control the system maintenance and operation. From an operational point of view, system quality is achieved by preventing problems and by continuously improving the system. Quality is the key for an effective and efficient distributed database system.

The process of developing the distributed database system is referred to as rightsizing. NASS System and Information Division initiated a number of rightsizing development activities. It is out of the scope of this paper to assess the maturity level of NASS systems. However, the maturity framework could be applied to improve NASS Standard Processing Technology and its LAN-base general purpose systems.

Technology

The second critical component of the distributed database system is **technology**. Included in the technology are data base management systems, micro processors, network facilities, development tools, and user interface tools. All of these technological aspects must be considered.

The fundamental technology is the Data Base Management System (DBMS). A true distributed DBMS system provides users with simultaneous update capability of multi-vendor databases residing on different platforms. DBMS vendors incorporate this feature into their product lines at various levels. Relational DBMS systems encapsulate the flexibility and transparency of data access. Moreover, the distributed DBMS needs to be enhanced with the object oriented technology which provides a high level integration of complex information; i.e. images, documents, video and audio with the advanced hardware.

CPU, memory, I/O throughput and disk storage are essential items for capacity planning and configuration management. A low end Reduced Instruction Set Computer (RISC) is three times faster than Intel 386 microprocessors. A configured RISC computer or symmetric multi-processors can be as powerful as an IBM 360 mainframe computer. In the last ten years, the computing price performance has dropped continuously from $10,000 per Million Instructions Per Second (MIPS, a way to measure computer performance) to less than $1,000 per MIPS. The openness of the computer architecture strengthens competitiveness among hardware vendors.[1.]

The local area network is a cost effective network design, which allows users to share resources; i.e. printers, software, and disk storage, at a local level. The wide area network, such as FTS2000, preserves users' access to the mainframe and computers at other locations. Electronic mail messages, network file sharing, and the access to the heterogeneous computing environments can be implemented with appropriate communication gateways, routers, and bridges. Conforming to the standard link, transport and inter-connect communication protocols, 10 BaseT, x.25, x.400 and TCP/IP standards, is mandatory for an efficient network arrangement.

The high performance computers and network facilities contribute to high quality distributed DBMS. Operating Systems are the major ties between a quality distributed database system and a high performance computer. It is essential that the operating system is open and portable on various platforms. IEEE's POSIX standard clearly specifies the requirements of a portable operating system. All operating system vendors strive to conform to this standard with a set of common frameworks.

Security is one of the major problems in an open and distributed computing environment. Per the DoD Orange Book, security practices (in order of increased security, C, B, and A) must be considered in the distributed computing environment. Adequate security administration prevents a malicious user from purposely locking up the system.[2]

Graphical User Interface (GUI) is one of the most revolutionary changes to the human/computer interface. It has changed from a terse, character orientation to familiar windows, icons and menus interfaces. WYSIWYG (What You See Is What You Get) and X Windowing are the standard representations for user interfaces, which allow users to retrieve and manipulate complex data types and large databases in an appealing and comprehensive manner.

The major risks involved in the development of a distributed database system are the dependencies on the existing information systems, commercial software, hardware and communication products. It is especially critical in the area of rapid changing technology, demanding network management, complex re-engineering effort and incompatibilities among products. The software packages in Remote Procedural Calls (RPC), Application Programming Interface (API) techniques, Standard Query Language (SQL), and application and system administration tools provides a degree of independence. Without step-by-step refinement and analysis, the integration and testing of software packages can throw the schedule and budget off tract.

As might be expected, with the 45 State Statistical Offices, the planned distributed database environment in NASS will combine FTS2000, advanced client-server solutions, PC-mainframe connectivity, and WINDOW software. NASS continues to improve these tools by refreshing software, hardware, and communication components.

Implementation

The third critical component of the distributed database system is **implementation**. To fully exploit the new technology, re-engineering systems are developed for re-designed business processes. Thus, the new technology drives the new business processes and vice versa. Most of today's development work centers on re-engineering of existing systems. It requires a comprehensive abstract and analysis of the data environment, processes and interfaces with associated systems. The implementation of any new system requires the understanding of the artifact of the existing system's environment.

Traditionally, the system development life cycle distributes its efforts as follows: 30% in design, 30% on coding, and 40% in testing. The testing effort of some NASS systems is as high as 80%. The purpose of DPP is to increase the system quality, reduce the ratio of the testing and maintenance effort, and to enhance the productivity of developers and end users. A typical defective preventive process in the system life cycle is to have an analysis team perform the code inspection and to have an action team formulate the improvement actions. With the early visibility of the possible defects in the implementation, DPP ultimately seeks preventive actions and cuts down the time and schedule in testing, integration, and maintenance thus reducing life cycle cost. In 1990, Hughes Ground System Group, by adopting DPP process, experienced a 50% increase in Cost Performance Index (CPI) and a turn over rate below 10 percent.[3] The effect of implementing a distributed database system decreases is that the cost of the system administration, data processing and the management of multi-vendor computing environments is under controlled, reliable and predictable.

It takes proper plans and strategies to effectively move the information among various platforms. The maturity framework discussed in the Strategy section defines optimization as the highest maturity level. Optimization does not exist in the real world. Progressive improvement of standards and procedures, database administration, configuration management, and security administration are achievable.

o Standards and procedures are improved with built-in human intelligence. They are defined, documented, and can be measured in a quantitative way. The automation of processes and procedures requires little human intervention.

o The database administration (DBA) functions include establishing procedures, setting standards, and educating users. Two most important DBA functions are data dictionary and data recovery. Data Dictionary contains process information of metadata, where the active reference of data is created automatically. For the re-engineering work, it is essential that the data repository is clearly defined and that they are mapped to each other in the existing system and the new system.

o Another determinant factor of a quality distributed database system is configuration management. Only when the configuration of baseline products and processes is manageable and controlled, can the autonomy of resources, facilities, vendors, systems, data, and procedures be obtained. Thus, risks start to decrease and productivity increases.

o Implementing a good system requires not only technology but also a sound and secure environment. Security administration is an example of the defect preventive process for secured business practices. It must be considered.

NASS implemented PC Summary, County Estimate, AGI (agricultural information), PC Ole (list overlap), ELMO (Enhanced List Maintenance and Operation), and other LAN-based systems. They provide interfaces to the existing processes, data, and systems residing on the mainframe. NASS enforces change control and security administration on its LANs and mainframe as part of the configuration management.

Summary

Procedures, data and application systems continuously evolve. In order to meet end users' requirements in today's distributed computing environment, continuous quality improvement is required. The maturity level assessment and the defect prevention process help to accommodate these requirements. For an effective and efficient distributed database system, the three critical elements of strategy, technology, and implementation must be thoughtfully considered.

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