Policy Systems:
The Integration of Information Technology
into Policy Analysis, Planning, and Program

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Abstract:

We define a policy system to be a collection of hardware, software, communication technologies, persons, procedures, protocols, and standards driven by and for the purpose of advancing a public organization's mission in regard to policy analysis, planning, and program evaluation decisions. While policy systems already exist in practice, we believe that they have not been identified and studied as a separate, distinguishable area of information systems. They have components and patterns of use that could benefit governments of all levels in carrying out policy making. We propose principles for building policy systems, identify their components, discuss how they address the complexities of policy making, illustrate them with several examples including our own policy system built for a local government agency, and distinguish them from related systems such as management information systems, decision support systems, and collaboratories.

Keywords:

Policy analysis, information technology

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I. Introduction

Policy analysis is generally regarded as a cottage industry, one in which craftsmen apply their unique talents, knowledge, connections, wit, and skills to turn out one-off analyses. A well-known policy analysis guide (Bardach 2000) underlines this point. Bardach's eightfold path to policy analysis is the familiar waterfall model of systems analysis and design, modified for policy analysis. In this model, one step flows after another in a linear fashion from problem definition to implementation and operation of programs. As such, it thus has steps, approaches, methods, and so forth for solving new, unique problems on a one-time basis. Step two is "Assemble some evidence." This step and the other seven will remain important for policy analysts, but at least for agencies having clear-cut missions, is it not possible to build and maintain policy systems that already have collections of information and data ready for use? It may be necessary to collect additional information, but should not core information already have been anticipated and pre-built?

Thirty years ago, management was in a similar state. COBOL programmers wrote one-off programs and files that bore their unique styles and imprints. The advent of database systems made possible management information systems (MIS). These systems are based on pre-built computer code that is reused within given contexts rather than being programmed from scratch for each application. MIS revolutionized management, making information readily available to all staff, regardless of position on the organization chart, and thereby eliminating the need for much of middle management. The benefits of policy systems, as we develop in this paper, are likely quite different but potentially dramatic as well.

We think that in practice, that there are already and have been policy systems in place, supporting and sustaining policy analysis. Some of these are in think tanks like RAND, many are in institutes of various kinds in universities, and others are special governmental units like the Congressional Research Service. These policy systems utilize information technologies in combination with models and analyses to support policy making. We suggest that academics need to study the examples that already exist and build a new field of policy systems. This paper provides one start for this activity in terms of policy, planning, and program evaluation in local government agencies.

In this paper we present a theoretical framework for policy systems and illustrate this theory to a case study of an actual policy system used for elderly services planning. We find that our system is responsive to real needs of practitioners, representative in terms of policy systems components, and conforms to key principles that we introduce below including access, openness and replication, analytical capability, and information asset management. Nevertheless, much needs to be done for this system, and like others developed in an academic setting, to be integrated into daily use by practitioners. Moreover, there are significant opportunities for researchers to leverage the literature in technology adoption and evaluation in order to quantify the impacts of policy systems on organizations and the citizenry.

The outline of the paper is as follows. Section II presents a theoretical framework for policy support systems, based on academic research and current practice. Section III introduces the case study on which the policy system described in this paper is based: elderly services in Allegheny County, Pennsylvania. Section IV describes a prototype "policy shop" intended to meet the needs of multiple stakeholders interested in planning for elderly services provision. Section V concludes and identifies some next steps for this research.

II. What is a Policy System?

We use the terms "policy system" and "policy shop" interchangeably to be a collection of hardware, software, communication technologies, persons, procedures, protocols, and standards driven by and for the purpose of advancing an organization's mission in regard to policy analysis, planning, and program evaluation decisions. A policy system supports activities that change the underlying structure of public goods and service delivery systems. In contrast, MIS supports management and operations, activities that strive for efficiency within established organizations and programs. To make this distinction more precise we offer the following definitions:

- *Policy Analysis* – addresses perceived gaps between the current and desired states of the world. The policy problem is stated in terms of symptoms of *gaps*, for example, imbalances between the supply and demand of quantities such as public services. Stakeholders and their positions are identified. Major policy alternatives are identified

and explored in terms of feasibility through deliberative processes. A decision is made in terms of a policy approach or direction.

- *Planning* – concerns allocation of capital, human, and other resources to long-term solutions. Planning decisions are on infrastructure, physical facilities, new organizations and programs, etc.
- *Management* – has the objective of efficient use of resources within established organizations and programs. Decisions may be made in regard to trends or seasonality in demands for services, and the mix and levels of services provided to accommodate variations in demand and costs of resources.
- *Operations* – deals directly with individual service deliveries with decisions made on eligibility, registration, scheduling, follow-up, etc.
- *Program Evaluation* – makes a determination if a program's use of resources is efficient and if its outputs are effective in accomplishing the program's objectives.

If further elaborated with subcategories, this classification yields a form of waterfall model or logical phases for public sector decision making. For example, a subcategory of policy analysis is *define the policy problem*: a) determine that an important gap exists between the existing state of affairs and a more desired state that is or will be on the political or administrative agenda of a government and b) collect or extract information to describe symptoms of the gap, possible approaches for a solution, and experience with similar solutions elsewhere.

A fully elaborated public policy waterfall model is the basis for classifying variations in policy systems. For example, the Congressional Research Service (CRS) is a policy shop that operates at the highest level of the waterfall (define the policy problem). CRS attempts to identify policy problems a year in advance of their consideration by Congress, and collects information for this purpose. The National Coalition for Dialogue and Deliberation holds technology-enabled town meetings on policy issues such as the meeting held in Washington DC in November 2003 with 3,000 residents to make recommendations on the city's budget (National Coalition for Dialogue and Deliberation 2004). This is a form of policy shop that carries out policy analysis in a modern town meeting format. The work that our students have done in the e-Policy Shop, presented below, addresses designing and planning facilities for the delivery of

services. Similarly the policy system presented by Gant (2004) focuses on multiple stakeholder support for planning at the local government level. The system described by Dawes and Pardo (2004) for evaluation of homeless programs is a policy shop at the evaluation level. Clearly policy shops can have different purposes and activities depending on many factors, including where they fit into the waterfall model for policy analysis.

The Complexities of Policy Analysis Addressed by Policy Systems

Retention of technical and analytical staff is a problem in government. Skilled staff members often move on to better positions in or out of government. If a key person leaves a policy system, the system nevertheless has resources to move on smoothly. That person's contributions will have been captured as organizational assets and be a part of the system. The person's data will be accessible, updateable, documented, and ready for reuse. Likewise the person's models will be cataloged, retrievable, in standard software packages, documented, and ready for reuse.

Private sector decision making is driven by profit maximization; whereas, public decision making must accommodate multiple criteria and stakeholders. Policy decisions and plans for new programs and facilities in a government directly impact the government's citizenry; for example, a new facility for drug treatment may be planned for "someone's back yard" or a teenager might need drug treatment. Inevitably there are multiple stakeholders who need a voice in policy, planning, and evaluation decisions. The potential of increased civic engagement and deliberation of policy issues in digital government is directly supported by policy systems. Indeed policy systems have as a major purpose enabling increased civic engagement.

It is well known that in practice projects do not proceed linearly from start to finish as conceptualized in the waterfall model (e.g., Larman 2003). Analysts instead must repeatedly cycle back to earlier phases of a project, even the very start of the project, because of challenges made by stakeholders and other dynamics in the process. For example, in many cases, planning has long horizons and the planning process must proceed incrementally. An example is site selection and construction of new facilities for a service where budgets and other resource limitations require staging over many years. Each time planning for a new facility is approached, it is necessary to revise data, models, and analyses. Stein (1995) has suggested that organizational memory be maintained in information systems for reusing such resources. A

policy system preserves data, models, and information for reuse and updating to provide for effective and efficient deliberation.

Principles of Policy Systems

Underlying a policy system are principles that support deliberation and involvement of stakeholders and citizenry. These principles include:

- *Access* – Data, metadata, procedures, white papers, reports, evaluation studies, etc. should be readily accessible from a Web site.
- *Openness and Replication* – There should be sufficient data and information available so that stakeholders can verify conclusions, replicate them independently, or form their own conclusions.
- *Analytical Capability* – Stakeholders should be provided on-line tools to probe conclusions or propose new solutions. O'Looney (2003) has made similar statements in terms of on-line decision support systems and simulations for civic engagement on e-government Web sites.
- *Information Asset Management* – Governments must invest in systems that maintain information as infrastructure for decision making and civic engagement. Valuable data should not be located on one analyst's desktop computer, but be widely available as an organizational asset.

Policy System Components

A large number of components can be used to construct policy systems. Examples include:

- *Staff* – Policy analysis, planning, and program evaluation require modeling, a complex undertaking that requires professionally educated staff members, such as the master graduates of public policy schools. A policy system structures the work of such staff and makes it more feasible for them to be successful. Many technical and analytical tasks have support through pre-built data collections and models, making it easier to produce needed results quickly, comprehensively, and accurately.

- *External Experts* – One way for local government to get needed expertise for policy and planning is to maintain a network of external experts who have access to and can contribute to the policy system. Universities are good sources for such experts, but so are related agencies and non-profit organizations.
- *White Papers* – With a mission, such as providing human services for youth, it is desirable to have experts convene from time to time, and examine critical topics such as emerging trends in demographics, potential changes in relevant laws and funding, state-of-art interventions, etc. in a series of white papers that define policy issues for study. These papers should be publicly available and in terms that are accessible to the public. In turn, white papers drive the collection of data and construction of models for use on an ongoing basis.
- *Data Warehouse* – Data relevant for policy analysis come from aggregations of internally-generated transactions data and from external sources on target populations, environmental conditions, etc. Collected and aggregated data need to have proper documentation on their field definitions, code tables, purposes and limitations, biases, discrete event impacts, and related entities. An additional need is to have procedures documented and programmed for inputting, cleaning, aggregating, and updating data. For many purposes, data need location identifiers and to be spatially enabled for processing in a geographic information system (GIS). Data privacy must be maintained for micro-level data.
- *Standard Software* – All staff and external experts need to use a standard set of software packages and analytical tools. Examples include database, GIS, statistical, and Web development packages. Software standards simplify training of new staff and facilitate reusing policy and planning models.
- *Model Base* – Certain models need to be built and then maintained for reuse. An example is an on-line, interactive model that estimates the demand for a new service delivery facility. When planners go about the business of identifying and plugging gaps in service delivery systems, they need an analytical capacity to estimate demand and size a facility's capacity. Decision models need to include functionality to conduct sensitivity

analyses and other means to identify and probe the uncertainty in models. Models must be stored as accessible and documented assets of the organization.

- *Web Site* – All of the features above need a back office system for construction and maintenance of components, and also a Web site for access by government staff, federal and state government staff responsible for grant making, stakeholders, external experts, and concerned citizens. We present a simple example of such a shop later in this paper.

Policy Shops versus Collaboratories

Policy shops are driven by the policy agenda and politics. A sister system in science and other research settings is the *collaboratory* (U.S. Department of Energy 2004):

> "Through collaboratories, researchers can share access to facilities, large datasets and environments, support the frequent interactions needed to address complex problems, and speed up discovery and innovation…The fusion of computers and electronic communications has the potential to dramatically enhance the output and productivity of US researchers. A major step toward realizing that potential can come from combining the interests of the scientific community at large with those of the computer science and engineering community to create integrated, tool-oriented computing and communication systems to support scientific collaboration. Such systems can be called collaboratories."

The activities and contents of collaboratories are driven primarily by the literature of a field, and perhaps sometimes for some areas of research, by policy needs. While scientists may compete to be the first to produce new research results, they tend not to have the problem of dealing with multiple criteria and stakeholders. Thus while there are similarities between the technologies of policy shops and collaboratories, their use and support needs are quite different.

III. Case Study: Elderly Services in Allegheny County, PA

In this section we present a case study on elderly services provision in Allegheny County, Pennsylvania that motivates the design of a policy support system. We first discuss national data on the elderly population and focus specifically on the elderly population and relevant services within Allegheny County. The elderly population in the United States has increased in size and

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in proportion to the overall population throughout the 20th century. These trends are expected to continue over the next 50 years, as the "baby boom" generation enters retirement years. "Middle-series" population projections estimate that the population of those 65 or older, which increased from 9.9 percent of the U.S. population in 1970 to 12.6 percent in 1990, will increase to about 20.3 percent in 2050 (Federal Interagency Forum on Aging Related Statistics 2000). Moreover, services for elderly persons—persons aged 60 or more—are in high demand and are given prominence by advocates for the elderly. These services include home-delivered means for the homebound, transit for those facing mobility obstacles, and facilities with on-site services such as senior centers.

A recent analysis of census data supervised by the authors[1] found that while Allegheny County had the highest number of elderly persons in Pennsylvania and is 13th in the U.S. in this category, the numbers of persons over 65 had actually declined between 1990 and 2000. After 2000, aging younger cohorts will probably result in a net increase in the elderly population.

Though the elderly population is well-represented in census tracts throughout Allegheny County, the greatest concentrations of elderly population are found in the city of Pittsburgh and surrounding first-ring suburbs. However, between 1990 and 2000, among all age categories of persons 55 and older, suburban Allegheny County showed either smaller population decreases or larger population increases than the city of Pittsburgh. Long-term secular patterns of suburbanization in Allegheny County are likely to require that elderly services, such as senior centers, respond creatively to the changing spatial distribution of elderly clients.

In Allegheny County, services for seniors are coordinated by the Area Agency on Aging (AAA), a unit of Allegheny County Department of Human Services (Allegheny County Department of Human Services 2004). Serving about 79,000 persons per year, AAA is the single agency in Allegheny County designated to receive Older Americans Act funding through the Pennsylvania Department of Aging for the purpose of providing services to county residents aged sixty and older. Nearly all of AAA's $41 million budget is provided by state and Federal sources, and 88 percent of state funding is derived from revenues associated with the Pennsylvania State Lottery.

[1] All references to field data collection are contained in printed reports available from the authors upon request.

AAA serves as an umbrella agency for the planning, coordinating and advocating for a comprehensive service delivery system to meet both the short- and long-term needs of the elderly. This is accomplished through contracts with more than 159 agencies that provide a variety of services. One service that has been the focus of research by these authors (Johnson, Gorr and Roehrig 2004) is *senior centers*, facilities for elderly adults who live independently that provide services such as lunchtime congregate meals, socialization/entertainment, counseling, volunteer activities, health assessments, meals to the homebound elderly and infirm and referrals to other service agencies. Home-delivered meals are also delivered by organizations not affiliated with senior centers; for example, faith-based institutions, throughout Allegheny County (Gorr, Roehrig and Johnson 2001).

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Other important senior services include: home-based care, a mechanism by which frail seniors can receive health care and assistance in daily home management tasks in such a way as to preserve their independence; adult foster care, a program in which independent adults take responsibility for care of frail elders in their own homes; on-demand transportation such as dial-a-ride; protective services, which enable AAA employees to advocate on behalf of seniors who may be abused or neglected, and senior companions, which match able-bodied seniors with other seniors needing periodic social contact. The choice of an appropriate mix of these services is done via a support services assessment, initiated by the consumer and coordinated by professional care managers. Recent efforts by AAA to evaluate and redesign its services and administrative structure have resulted in the Senior Center Quality Standards Project, an initiative to measure the level and quality of services provided by senior centers, and the Care Management Change Initiative, a program to better align administrative resources with client needs.

A key building block for policy planning for elderly services is demand forecasting. While AAA has reasonably good measures on current usage of its various services, it does not have the capacity to estimate future levels of demand and determine the extent to which these demands can be met by the current configuration of services. As a result, AAA's current configuration of senior centers and HDM kitchens reflects a historic concentration of elderly in Allegheny County's urban areas, principally the city of Pittsburgh and gaps in coverage. For example, Gorr, Johnson and Roehrig (2001), using an interactive GIS-based heuristic to design catchment areas for 64 existing HDM kitchens in Allegheny County, found that about 17% of

total demand remained uncovered. Since this study used optimization techniques to design most-efficient routes and catchment areas that overlap as little as possible, we believe that this measure is a lower bound to the actual level of unserved demand. This sort of analysis requires extensive geographic information systems (GIS) and statistical expertise—expertise that we argue should be an integral part of a policy system.

Another key task in developing a policy support system for elderly services is identifying stakeholders and clarifying the needs that can be addressed through information technology applications. The primary stakeholder is AAA itself, which must determine how to align its services with the needs of its clients. Specific issues AAA must address include the location, capacity and service territories for its senior centers and affiliated HDM kitchens, and staffing and funding for its services listed above. County government must decide how much funding to request from state and Federal agencies and how to measure the effectiveness of the services that receive this support. Elderly service providers wish to maintain current service levels and reach as many clients as possible. Clients need the ability to choose high-quality services that are accessible and appropriate to their changing needs; they also represent a politically powerful lobby for retention and expansion of existing services. Foundations that support elderly services need the ability to assess funding needs and measure program outcomes. Citizens of Allegheny County and across the state wish to ensure that their tax dollars are used most effectively and their tax burden is minimized where possible. To the extent that funds for elderly services are allocated to local administrative units, municipalities represent another politically powerful stakeholder group. Universities can provide specialized analytic expertise to agencies such as AAA, but face the burden of making their research relevant and accessible to resource-limited practitioners. State agencies such as the Pennsylvania Department of Aging may prescribe administrative and service provision models to which local units such as AAA must adhere.

Quantifying and balancing the needs of these different stakeholder groups is challenging and not typically done in an explicit and comprehensive way by mission-driven agencies such as AAA, yet doing so is essential in order to design a policy system that meets current and future needs using best-available data and analytic methods. One approach is provided by Keeney's (1992) value-focused thinking methodology. The goal of this method is not to choose a site, service mix or catchment area for a particular facility but instead to address the more general problem of identifying fundamental values and preferences associated with elderly services

strategies. A decision problem consistent with this goal is then formulated and solved. Though we have not conducted stakeholder groups to identify fundamental values and preferences[2], we assert that our policy support system is consistent with the fundamental goals stated by AAA: "enable people, age 60 and older, to remain safe, healthy and active while living independently in their own homes." (Allegheny Department of Human Services 2004).

The final step in the process of developing a policy system is then producing specific analytic tools that are embedded in an information technology application accessible to various stakeholders. One example of such a tool is a spreadsheet-based demand forecasting model for senior center services. Another application defines the suitability of specific spatial units such as municipalities for senior centers on the basis of multi-criteria weighting with user-selected characteristics such as local amenities, health care resources, access to public transportation, and so on (InfoLink Program 2004).

Given estimates of demand for services and site suitability, decision models can then define specific policy alternatives that optimize chosen criteria. One such decision model designs a network of senior centers across a large service area using integer programming (Johnson, Gorr and Roehrig 2004). Here, the goal is to choose locations of senior centers and assign spatial units of demand to specific centers to optimize the sum of average travel distance and unsatisfied demands, subject to funds availability. Another relevant application is a decision support system for designing a network of home-delivered meals kitchens and their associated delivery routes using an interactive, GIS-based heuristic (Gorr, Johnson and Roehrig 2001). This application uses forecasts of demands for home-delivered meals and known capacities for current and potential kitchens as the basis for user-defined HDM kitchen sites and system-generated delivery routes.

IV. A Policy Support System for Elderly Services Provision

In this section we present an example of a policy shop built in a master-student project course in the Heinz School for the Allegheny County, Pennsylvania Area Agency on Aging (AAA). The purpose of the resulting "e-Policy Shop" was to identify gaps in the coverage of the

[2] Johnson (2003) has developed a decision modeling methodology for location of community corrections centers that uses value-focused thinking to identify a "decision opportunity" (a problem to be solved) and a "values-based strategy" (a specific decision problem whose solution provides specific guidance to policy makers).

elderly population in Allegheny County by senior centers and to provide a planning model for estimating the impact of new senior centers for filling the gaps[3]. The resulting Web site[4] includes white papers, data, documentation, standardized software products, models, tutorials for data preparation and modeling, and results. This example illustrates a number of elements that we feel are important in the design and implementation of a policy shop. At a higher level of abstraction, these include issues tracking and forecasting, technologies for institutional memory, and modeling, and stakeholder involvement.

Issues Tracking and Forecasting

Policy making requires understanding the issues currently and potentially important to the government agency in question and stakeholders. While some issues are new, others tend to recur. For the former, some means of predicting them, their timing, and importance, is useful. For the latter, it is important to be able to draw upon the facts, stakeholder positions, and outcomes of earlier deliberations.

For major, long-term policy issues, a policy shop should maintain a collection of documents that represent all sides of the matter in a concise but complete way. White papers, written or edited by experts, can be solicited or perhaps commissioned. These would include historical information or forecasts about local conditions such as demographics of target populations, potential impacts of pending legislation, innovative programs implemented in other regions and their outcomes, and predictions of the impacts various options could have. Other sources of background material include newspaper articles, editorials and opinion pieces, and transcripts of relevant workshops and public meetings. More and more, this information is available in electronic form, so can be catalogued and easily searched.

In looking ahead for policy issues near the horizon, management techniques such at SWOT (strengths, weaknesses, opportunities and threats) analysis can be used. Data-oriented methods are also convenient for forecasting policy elements of issues. For example, underlying trends of major target populations are available from the US Bureau of the Census and other sources. Coupled with geographical analysis and display tools (illustrated below), demographic data are an excellent way of identifying problems before they occur. In the same vein, funding

[3] AAA has reviewed, approved and used the e-Policy Shop; however, due to administrative and budgetary reasons the site is not currently managed by AAA.
[4] URL: http://itclass.heinz.cmu.edu/aaaweb; Login: heinz\aaaweb; Password: heinzaaaweb.

projections are obvious indicators of potential opportunities and dangers. The e-Policy Shop has a white paper on demographic trends of the elderly population in Allegheny County, including forecasts to the year 2010, that has been widely used by the Area Agency on Aging (Chen 2002).

Technology Considerations

A minor revolution in the MBA training of business managers occurred about 10 years ago, with the introduction of the electronic spreadsheet into the management science curriculum. Soon after, this integration of computer software with traditional modeling instruction has been carried over to professional programs in public policy. The ability to solve real policy and planning problems using optimization, forecasting and simulation has been a boon to both corporate managers and policy specialists.

More recently, advances geographic information systems, databases and data-mining tools have proven to be a boon for those local government officials and their staffs who have seen the benefits they provide. The wider availability and lower prices, however, for these software tools presents a new problem. Technology-inspired analysts and other staff can often develop strong preferences for one tool over another, essentially equal one and this can cause the equivalent of the "operating system wars" of an earlier generation. Planning for the introduction, phase-in, and eventual phase-out and replacement of policy shop software is a difficult issue. Standardization on software, or better, adopting software standards for functionality and interoperability is the solution.

The selection of software for the AAA policy shop illustrates these problems, and the software mix eventually chosen represents a reasonable (but not unique) solution. The requirements include the ability to perform spatial analyses over the county, taking into account current and future population demographics, likely demands on senior services facilities, availability of transportation and local amenities, current and projected funding, and much else. In addition, a common set of analysis tools need to be available for policy makers and planners, and a set of related "what-if" tools need to be available to external stakeholders.

At the heart of the software suite is a geographic information system, specifically ArcView (Environmental Sciences Research Institute 2001), and its Internet-capable sister ArcIMS (Environmental Sciences Research Institute 2002). These products, while not inexpensive, can read industry-standard file types for base maps (polygons for municipal

boundaries, lines for street networks, etc.) and standard flat database files, and display geographical and tabular information in a variety of ways. Additional database capability is provided by Microsoft Access (Microsoft Corporation 2001). The Excel spreadsheet (Microsoft Corporation 2001) provides a simple way of performing ordinary statistical procedures, optimization modeling, and simulations.

Finally, the power of these modeling, analysis and display tools is made available to users and stakeholders through the Internet, in the e-Policy Shop, using Web pages generated by Macromedia, Inc.'s Dreamweaver (Macromedia, Inc. 2004). This software allows policy shop personnel to create and maintain an informative, attractive, and consistent Web presence.

Sustainability

The software tools mentioned above, if used effectively, allow many types of spatial and numerical analyses to be performed, and make communication of the results understandable and compelling. But designing and implementing a model for a particular policy problem, at least in its broad form, is something that should only need to be done once. "Software reuse" has always been a goal of the software community, and this idea translates well to the notion of "model reuse". In order to accomplish this, good documentation is necessary.

It is all too common in software shops that the programmers hate writing documentation. In our experience, the same is true of model builders. But reusing or extending a poorly documented model, months after its initial construction, can be harder than building it in the first place. So, just as in software shops, a policy shop needs procedures in place that reward good documentation.

In the e-Policy Shop developed by our students, an entire component is devoted to tutorials and documentation as seen in Figure 1.

[Figure 1: Access to Tutorials for Reusing GIS Models]

Virtually all of the specialized knowledge needed to maintain and reuse models and analyses is recorded here. Students sometimes needed weeks to learn the tools and develop a useful model, but after documenting their effort, newcomers can effectively contribute almost immediately.

This is another form of, and a solution to, the "institutional memory" problem. Other kinds of documentation collected and stored in the e-Policy Shop include data file structure, instructions for file updating and cleaning, and complete model descriptions. Together, these make model refinement and extension to new circumstances a possibility on a day-to-day basis.

Model Assessment

Once a policy or planning model is conceived and built, there are several steps that remain before it is really usable. Traditionally, these are termed *verification and validation*, and *sensitivity analysis*. Verification attempts to show that the model output is a correct translation of the model inputs. So in a regression model, for example, it must be verified that the regression coefficients obtained agree with the theoretical expectations for the model. Validation, on the other hand, is the process of ensuring that the model bears a strong semblance to reality, that is, the assurance that what is being modeled truly bears on the problem at hand. In this case of forecasting demand for senior centers, estimation and hold-out data sets can be obtained from the full data set of client micro data, with estimated models used to predict client levels for the hold-out sample. Resulting forecast errors provide an accuracy validation. Finally, sensitivity analysis gives the interpreter of the model a sense of how conclusions drawn from the model might change if inputs change.

As an example of sensitivity analysis, consider a GIS-based model for the location of new meals-on-wheels kitchens (Gorr, Johnson and Roehrig 2001). Given meal capacities of the currently existing kitchens, any analysis of the need for new kitchens obviously depends on the size and location of the potential client base. Thus the model, which was designed to assess the benefit of locating a new kitchen within the existing group of kitchens, was first run multiple times, each time with a different distribution of potential clients. This analysis was itself repeated, with different assumptions on the fraction of the elderly population needing such a service. Only after this sort of sensitivity analysis can a planner gain confidence that the model is telling her something useful.

Once a model has passed the tests of verification, validation, and sensitivity analysis, it can be put to use. Typically a policy maker wants to examine multiple scenarios, and in those scenarios, the likely outcomes of several proposed policies. For some problems, this can be a long process. To facilitate policy assessment and shorten its time, it is valuable for these

scenarios and policies to be identified in advance of model building. The more the modeler understands the conditions under which his product will be used, the better he will be able to incorporate means by which a wide variety of scenarios and policies may be accommodated.

Access and Stakeholder Interaction

Policy and planning decisions need to be made as transparently as possible. To this end, allowing stakeholders to replicate, on their own, the analysis process that leads to a decision can be very valuable. The idea of a Web-based policy shop can help fulfill this need. Earlier we described a set of software tools that are "Web-friendly"; the models produced using them can be made available, in easy to use form, over the Internet. Stakeholders may then repeat the experiments conducted by policy makers, and perform their own "what if" analyses.

As an example, the e-Policy Shop described throughout this section makes available to the public some of its data sets, models (and tutorials for their use), and products (model results, reports, and so forth). Anyone willing to invest some time reading the tutorials and reports can download the model software and repeat an analysis, changing parameters at will. Two examples illustrate the possibilities.

In the first example, the problem is to decide the suitability of potential new senior centers, to be located in Allegheny County. A second student project, conducted by high school students in the Heinz School's InfoLink program (http://heinz.cmu.edu/infolink), produced a Web-based GIS of Allegheny County, along with the boundary of "covered" elderly population from the e-Policy Shop that identifies gaps; bus routes; existing senior centers; locations of medical facilities, drug stores, banks, and other amenities, and possible locations for new centers, are presented in an interactive Web format[5].

A "suitability index" by municipality for new senior center locations weights multiple criteria including factors mentioned above plus number of elderly population and number of residents below the poverty level. See Figure 2. While not implemented by the project team, it is possible to give users the ability to adjust the weights in the suitability index, according to their own perceived relative worth, to find good alternatives for new center locations. Users can

[5] URL: http://itclass.heinz.cmu.edu/infolink02/web, GIS Suitability link; User ID: Heinz\aaaweb; Password: heinzaaaweb.

interactively change the Web based map to display each of the input factors separately and zoom into small areas for analysis. See Figure 3.

[Figure 2: Covered and Suitable Municipalities for Senior Centers, Allegheny County, PA]

[Figure 3: Covered and Suitable Municipalities for Senior Centers, Western Allegheny County Detail]

In the second example, a spreadsheet model to forecast elderly demand for senior centers can be downloaded, along with data sets and instructions for use. Here again, a user can replicate analyses reported by the policy maker, and modify model parameters to do an independent sensitivity analysis.

System Benefits

Transparency in local government decision making is an oft-stated goal, but is often difficult to achieve. Town meetings allow open discussion, for example, but to be truly useful stakeholders must arrive prepared with an understanding of the basic issues and facts. Other means of consensus building require the same level of background and knowledge. Policy systems as described here are one way to foster this knowledge.

The tools needed to provide what can amount to a quantum jump in stakeholder awareness are relatively modest in today's Web environment. A planner or policymaker must be willing to learn, or have her staff learn, the variety of uses to which software products such as those mentioned above may be put. But with proper organization and documentation, the learning curve can be flattened, institutional memory lengthened, and better outcomes anticipated.

Related Information Technologies and Methodologies

There is nothing new under the sun. All of the technologies and methods that we envision already for policy systems exist in various forms elsewhere. New here is the integration of

selected technologies for the policy, planning, and evaluation levels of governmental decision making in policy shops. Below is the beginning of a list of relevant and related technologies.

- *Data warehouse* – inputs data from disparate sources for aggregation and use in decision making.
- *Decision support system* – provides data, models, and user interfaces to support partially structured decision problems.
- *Multi-Criteria Decision Making* – provides models and methods for evaluating and displaying alternatives in terms of multiple criteria.
- *Web Services* - allow Internet clients to use data and tools that run on remote servers and to incorporate results into their projects.
- *Data Confidentiality and Security Methods* – protect the confidentiality of data while allowing their use in analyses.
- *Geographic Information Systems* – allow display and interactive use of mapped information on target populations, distribution of service facilities, etc.

V. Conclusion and Next Steps

This paper has argued that policy systems, though inspired by current applications associated with actual practitioners, and based on existing theory in information systems design, spatial analysis, values elicitation, group deliberation and decision support, and implemented using widely-available software tools, represents a novel tool for policy design and implementation. We believe that a judicious use of information technology that is policy-aware and problem-driven can fill this gap. Our case study of elderly services in Allegheny County, Pennsylvania provides an illustration of these ideas. A prototype policy support system, the e-Policy Shop, while preliminary in many ways, demonstrates the ways that data, expertise and models can be combined to enable planners to generate alternatives related to location of senior centers that are based on current evidence, best practice and appropriate models.

Research in this newly-defined domain is in its infancy. We recognize the need to continue work on professional-quality policy systems that are used on a daily basis to support actual decisionmaking. In doing so, researchers will certainly modify the theoretical framework

we have developed, and identify novel uses of data, models and IT applications. One area deserving of greater attention by researchers, and one not explored in detail in this paper, is policy systems evaluation. Research in this area encompasses technology adoption and diffusion and cost-benefit/cost-effectiveness analysis. There are significant unanswered questions regarding the effects on outcome measures of equity, efficiency and effectiveness associated with use of policy support systems. We look forward to future research that will bridge yet another gap in policy analysis: that between information systems implementation and organizational and client population outcomes.

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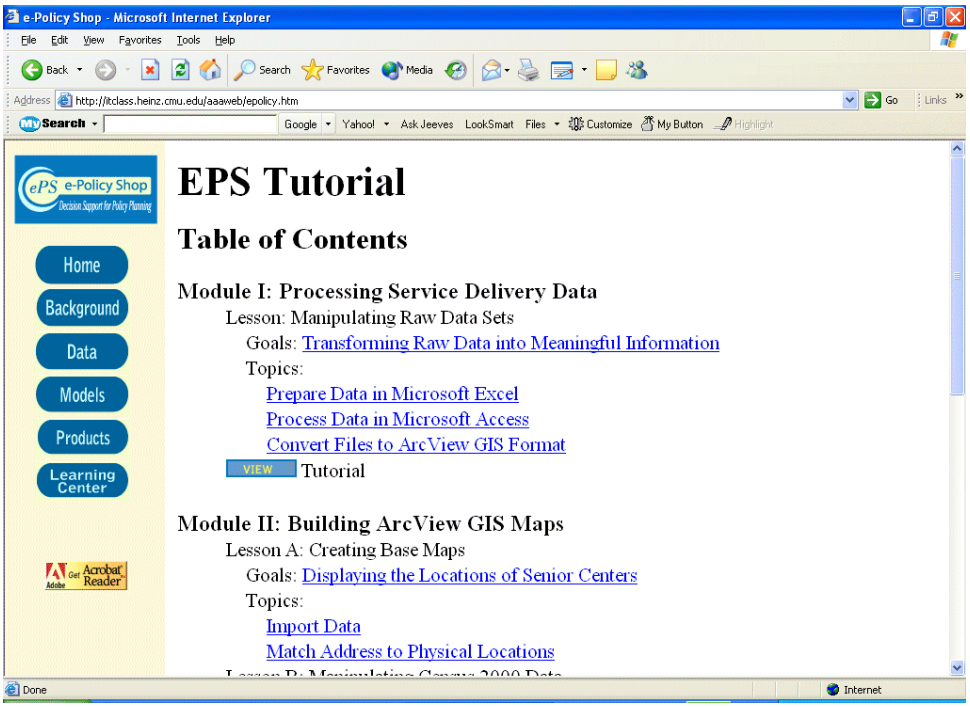

Figure 1: Access to Tutorials for Reusing GIS Models

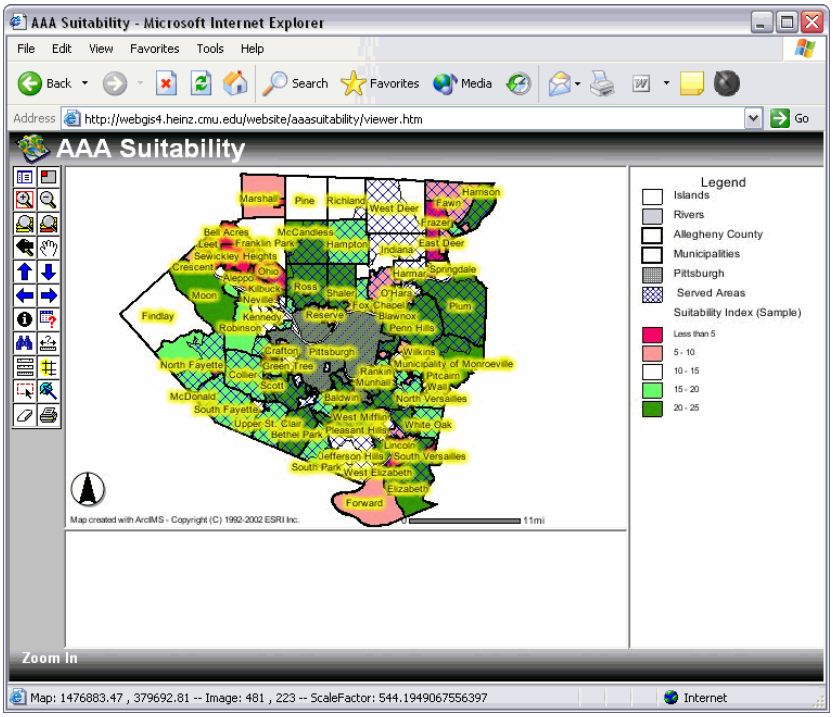

Figure 2: Covered and Suitable Municipalities for Senior Centers, Allegheny County, PA

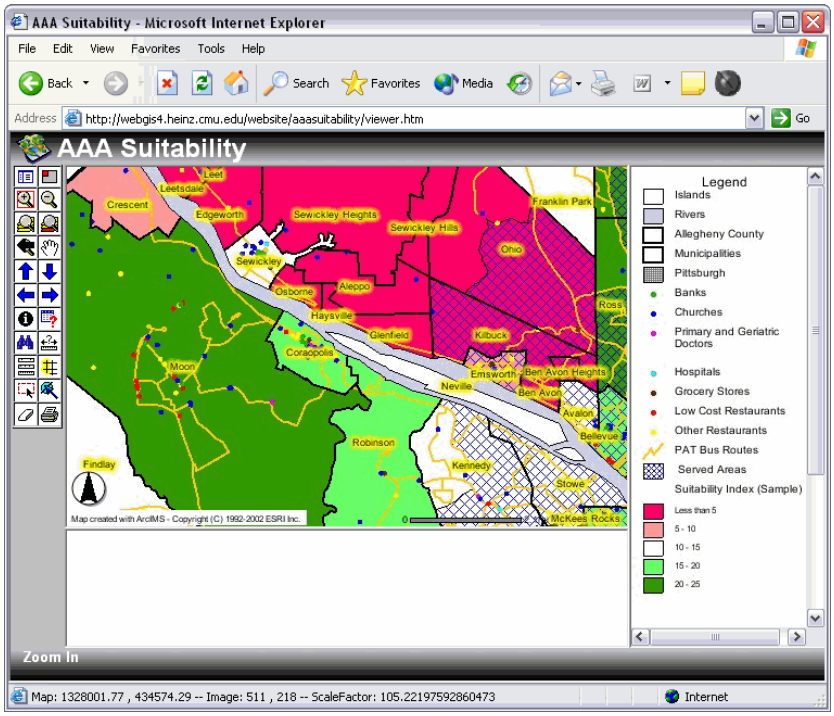

Figure 3: Covered and Suitable Municipalities for Senior Centers, Western Allegheny County Detail