# A Typology of E-Governance Operational Information Systems Tasks

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**ABSTRACT**

*In this research a typology of information systems tasks is developed based on existing dimensions reported earlier in the literature. This typology allows one to classify not only the traditional e-governance information systems, but also lay the foundations for technologies/methods yet to be developed. It also provides a prescriptive element in designing current and future e-governance information systems. The resulting framework also provides one approach for government officials in accessing and managing the risk associated with developing, implementing and managing future e-governance projects.*

***Keywords:*** e-governance, framework, project risk.

## 1. Introduction

Over the last decade the investment in Information Technology (IT) as a proportion of the overall government expenditure has grown dramatically. Agencies believe that such extensive investments in IT can help serve its citizen more effectively. However given the size of such investments, it is imperative that the design, development, implementation and management of information systems are aligned with the demands of the environment and the available technologies. A mismatch results in a waste of precious government resources and result in a poorly served citizenry. Development and adaptation of information technology for e-government differs from development in the commercial sector in many ways. Many e-government projects have objectives that are harder to measure, are not motivated by profit and are funded and managed by governmental units that will continue to exist whether or not projects succeed. As a result the vary nature of government makes the accountability of many information technology projects difficult to impossible. When one considers the high rate of project failures in the for profit sector, the risk of failure for e-government project is greater. Among developing and transitional countries the estimates of failure are 35% total failures and 50% of the projects are partial failures (Heeks 2003).

Although the current IT literature is quite extensive, and the use of frameworks to guide research in e-government is not new, we believe that the existing IT literature does not provide the degree of specificity necessary to capture accurately the current and future governmental and technological environments. Heeks and Bailur (2007) found 10 of the 84 e-government research articles made use of a framework that was derived from a body of theoretical work. However the e-government typologies found in the literature generally focused on issues related to the type of user or purpose of the e-government system. Some examples would be typologies of the role of the citizen government interactions (Michel, 2005; Park 2006). In this research we develop a typology that focuses on two factors that could influence

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e-governance effectiveness and the degree of success or failure -- information systems complexity and environmental uncertainty. A properly built typology is very useful in that it not only allows for classification of various information systems applications, but also defines salient variables and how to measure them. Hence, properly constructed and defined typologies lay the groundwork for theory development. To this end, we develop a typology that maps out the range of Information Systems (IS) tasks under various conditions of information systems complexity and environmental uncertainty faced by governments, thereby providing the basis for operational information systems tasks theory. This typology can be of use to both practitioners and researchers. It can help officials 1) ascertain the utility of various IS systems for their agencies, 2) help in guiding development choices such as methodology choices or the decision to use consultants, and 3) managing the expectations of the stakeholders. Researchers can also find this typology of use in that 1) it bridges the gap between the literature on organization theory/environmental systems and the literature on information management, 2) it can be generalizable across variations in technologies and environments, and 3) and it can be used to identify information systems tasks that are yet to be developed in the future. To ground our research, we will next examine the literature in theory development/typologies, information systems, and environmental conditions. Following this synthesis, salient dimensions are extracted to develop the typology. Finally, we discuss the applicability of this typology and provide directions for future research.

## 2. Literature Review

To develop our typology, we will first review the proper methodology for theory building and the corresponding definitions. Following this review, the IS literature in classification systems, frameworks and typologies will be examined relative to the theory building methodology and definitions. The applicable research in organizational behavior, organization theory and environmental uncertainty will also be relied upon.

***Theory building:***

In developing theory, it is essential to employ the proper methodologies and terminology. In this research, we will borrow from the typology building methodologies established in social science fields. Employing an appropriate theory-building process can help us improve our prediction (precision) and understanding (power) in the IS area (Dubin, 1969), and in turn establish a strong understanding of information systems phenomena (Zmud, 1998). In this research, we attempt to follow this methodology and employ the appropriate terminology. In developing any theory it is important to define the research question clearly. Ambiguity at this stage can be problematic, because if the boundaries of the theory are not well defined, the literature review becomes unfocused. In addition, theories are bounded by assumptions; such assumptions carry crucial information on implicit values, time and space. These assumptions need to be clearly stated in the research. Unfortunately, in many papers these assumptions are not clearly spelled out making it difficult to judge and apply them (Bacharach, 1989). For example, if a study was only conducted in the U.S. it might be bounded by cultural variables. Hence, the findings would be only relevant to American. However, if the study accounted for the cultural variables, it would perhaps be flexible enough (generalizable) to successfully apply to businesses in other countries. The more generalizable a theory the better it is. It is also essential that the unit of analysis is defined. For example, in psychological studies the unit of analysis is at the individual level. A unit of analysis identifies the entity or person for whom the research is being developed. Once the unit of analysis has been specified, it becomes possible to define the structural and process variables (constructs) (Melcher, 1976).

In typologies, the structural variables are the formal elements of a system. For example, in a human body the circulatory network would be considered a structural variable. This variable could be made up of two or more properties such as the heart, blood, etc. It is important that the properties are sufficiently defined, which can analytically be ascertained by asking whether 1) the properties can only be added together (additivity), 2) the combination of properties yield polar opposites (synthesis), 3) polar dimensions of the variables have logically consistent features of the same property (consistency), 4) the properties exist in terms of a state, rather than a relationship, and 5) the individual properties are conceptually defined so that they are independent of each other (Melcher and Melcher, 1980). Process variables are characterized by the activities that actually occur and are the results of the interaction of the various structural variables. For example, beating of the heart or blood flow would be considered as process variables and come about due to a number of structural variables including the circulatory and nervous systems (Melcher and Melcher, 1980).

Once the properties of structural variables are correctly defined, the various process variables can then be classified. To map out the process variables, the structural variables should be cross classified. Hence, four structural variables with three conditions each would lead to 81 cells (3x3x3x3) under which the process variable can be classified. This type of classification is the most precise, but contributes to a plethora of cells. To simplify the approach it is possible to group the structural variables into clusters, and then cross-classify the clusters themselves. The typology which results provides a basis for theory with the necessary precision for prediction and understanding.

### *Information Systems Theory*

In this research, our focus is at the operational level. In the current literature, many frameworks at the operational level do not have all structural variables specifically defined with corresponding properties affecting the power and precision of the model (Ahituv, Neumann and Zviran, 1989; Leifer, 1988; Fiedler, Grover and Teng, 1996), while others are not proper typologies (Iivari, Hirschheim, Klein, 2001). All theories are bounded (limited) within time and space assumptions. Time in this case refers to whether the model is applicable to only today's technology or is also valid for future technologies that are yet to be developed. Space refers to the location. If the model is only applicable to operations in the U.S., its utility might be somewhat limited. Also, a number of existing frameworks lack the generalizability to a range of technologies (Hackathorn and Karimi, 1988, Lee and Leifer, 1992; Pant and Ravichandran, 2001) or applications (Choudhury and Sampler, 1997). However, almost all of these frameworks are extremely valuable in developing our typology in that properties and structural and process variables can be found in this literature. In particular, Meyer and Curley (1991) provide two encompassing structural variables and a number of corresponding properties. Many of the earlier frameworks borrow heavily from the organizational behavior, organizational theory, and strategic management literature. In our research, we will also employ structural variables from the same areas, which will be explored next.

## 3. Toward A Typology of E-Governance Operational Information Systems Tasks

Three structural variables are identified in the organizational behavior/organizational theory literature, which are then combined with two structural variables from the IS literature. This framework is generalizable to differing environmental conditions and technologies. The unit of analysis is at the operational task level.

### *Environmental Uncertainty Structural Variables*

Seminal IS research borrows heavily from the organization behavior, organization theory, and strategic management research (e.g., Fiedler, Grover and Teng, 1996; Lee & Leifer, 1992; Leifer, 1988). For example, many IS models link the type of organizational structure with the degree of IS centralization and decentralization, thus providing recommendations on specific technological requirements such as hardware, database locations/distribution, locus of applications and systems boundary (Lee and Leifer, 1992). Likewise, we will also borrow concepts from organizational theories, but employ the more recent structural variables. The nature of the environment in terms of environmental certainty-uncertainty has been defined in various ways in the literature, and three structural variables of the environment have been identified that help make predictions about the kinds of environment in which different levels of perceived uncertainty are expected to exist: capacity/munificence, volatility/dynamism, and complexity. The properties of the three structural variables allow for additivity, synthesis, and consistency, and exist in terms of a state rather than a relationship; they are conceptually defined so that they are independent of each other.

Capacity or munificence refers to the degree to which the environment can support growth. Rich and growing environments create excess resources, which can help buffer the organization in times of relative scarcity; abundant capacity leaves room for an organization to make mistakes. Volatility or dynamism refers to the degree of instability in the environment. When there is a high degree of unpredictable change, it is difficult for organizations to accurately predict the probabilities associated with various decision alternatives. Complexity refers to the degree of heterogeneity and concentration among environmental forces. Simple environments are homogeneous and concentrated; complex environments are heterogeneous and dispersed. The capacity or munificence of the environment (abundant to scarce) can be defined by the following properties: relative rate of industry growth (rapid to none/slow), dependency on suppliers (low to high), dependency on purchasers (low to high), support of government (high to low), availability of capital (high to low), incubator organizations (many to few), nature of local labor market (abundant to scarce), and information accessibility (high to low). For example, outsourcing firms would be classified as operating within environments of relative abundance because of the rapid growth within the industry, low dependency on purchasers, high availability of capital, incubator organizations, and information accessibility.

The degree of environmental volatility or dynamism (stable to volatile) includes the following properties: turbulence (low to high), frequency of change (infrequent to frequent), discontinuities (low to high), speed of change (slow to rapid), predictability of change (predictable to unpredictable), and interconnectedness among organizations (low to high). For example, in the 1990s with the liberalization, Indian agencies were affected by a relatively volatile environment, because they operated under high turbulence, frequent changes in environmental forces, discontinuities, rapid change, and relatively unpredictable change. The degree of environmental complexity (simple to complex) has the following properties: heterogeneity of environmental forces (homogeneous to heterogeneous), number of environmental elements (few to many), diversity of environmental elements (low to high), distribution of environmental forces (concentrated to dispersed), balance among firms (balanced to unbalanced), monopolistic power of industry (high to low), concentration of industry inputs (concentrated to dispersed), concentration of industry outputs (concentrated to dispersed), diversity of industry products (few SIC products to many SIC products), and geographic concentration of industry sales and establishments (concentrated to dispersed). For example, the postal system operates under a relatively simple environment because of the homogeneity and concentration of environmental forces, small number of forces, balance among firms in the industry, relatively high monopolistic power of the industry, concentration of industry inputs and outputs, and few SIC products.

The cells emanating from the three structural variables can be clustered for simplification and ease of understanding. In this research we divide each structural variable into three regions: capacity/munificence (abundant, moderately abundant, scarce), volatility/dynamism (stable, moderately volatile, volatile), and complexity (simple, moderately complex, complex). This yields a total of 27 (3 x 3 x 3) α cells. In Figure 1 we look at the combination of the three structural variables.

For example, under environments with low uncertainty (abundant, stable, simple)- we might find postal units (α cell 1,1,1). As the capacity of the environment decreases (A) we find traffic police operating in one of the fast growing metropolis (α cell 3,1,1); whereas if the environment becomes more unstable (B) we would find the census agency (α cell 1,3,1). Similarly, operating within scarce, volatile, and simple environments (α cell 1,3,1) we might find the judiciary. As the complexity of the environment increases

(C) we might find customs (α cell 1,3,3), as the volatility increases (D), we could find the tax department, and as the abundance decreases (E), we could find the federal government (α cell 3,1,3) performing multiple tasks over a multitude of states. Under environments with moderate levels of uncertainty (moderately abundant, moderately volatile, and moderately complex - α cell 2,2,2), we find state and regional agencies. Finally, under environments with high levels of uncertainty (scarce, volatile, and complex - α cell 3,3,3) we would find disaster relief agencies.

Complexity Complex

| | | Capacity/munificence Abundant | | Scarce |
|---|---|---|---|---|
| | Volatile | α 1,3,3 income tax | | α 3,3,3 disaster relief |
| Volatility | | | | |
| | Stable | α 1,1,3 customs | | α 3,1,3 federal agency |

Complexity Moderate

| | | Capacity/munificence Abundant | | Scarce |
|---|---|---|---|---|
| | Volatile | | | |
| Volatility | | | α 2,2,2 state agency | |
| | Stable | | | |

Complexity Simple

| | | Capacity/munificence Abundant | | Scarce |
|---|---|---|---|---|
| | Volatile | α 1,3,1 census agency | | α 3,3,1 judiciary |
| Volatility | | | | |
| | Stable | α 1,1,1 postal units | | α 3,1,1 traffic police |

**Figure 1:** Combination of capacity/munificence, volatility and complexity variables (α cells).

By taking the diagonal combinations we generate a continuum for the nature of the environment: low environmental uncertainty (abundant x stable x simple), moderate environmental uncertainty (moderately abundant x moderately volatile x moderately complex), and high environmental uncertainty (scarce x volatile x complex). If a greater detail in the model is required, other cells can be combined with the respective environmental structural variables. The next section examines the respective information systems structural variables; the following section combines the environmental uncertainty variable with the information complexity variable.

***Information Systems Structural Variables***

Two structural variables are identified from the IS literature: the degree of knowledge complexity and the degree of technological complexity. These two variables encompass a wide range of technologies and information environments. The various properties for both structural variables allow for additivity, synthesis, consistency, and exist in terms of a state rather than a relationship; the properties are conceptually defined so that they are independent of each other. The degree of knowledge complexity can be defined by the following properties: breadth of domain (single vs. multiple), rate of change of domain(s) (low vs. high), depth of domain (common vs. expert), comprehensiveness of systems outputs (limited vs. extensive), breadth of information inputs (limited vs. range), ambiguity of information inputs (low vs. high), degree of information interdependence with outside organizations (limited to extensive), and uncertainty of information inputs (none vs. extensive). For example, conducting R&D would be considered high knowledge complexity given that the breadth of domain is often multiple, rate of change of domain(s) is generally high, depth of domain is usually at the expert level, comprehensiveness of systems outputs tends to be extensive, breadth of information inputs might have a large range with a high degree of ambiguity, degree of information interdependence with outside organizations is often extensive, and uncertainty of information inputs is extensive.

The degree of technological complexity has the following properties: diversity of platforms (single vs. multiple), diversity of technology (limited vs. extensive), database intensity (low vs. high), database location (centralized vs. distributed), diversity of information sources (few vs. multiple), and processor location (centralized vs. distributed). For example, a professor tabulating class grades on a grade sheet would be considered having low technological complexity given that a single platform is used (paper), the diversity of technology is limited, database intensity is low, database location is centralized, diversity of information sources is limited, and processor location is centralized. The two structural variables (knowledge complexity and technological complexity) can then be combined to examine information systems complexity. In this research we divide knowledge complexity into three regions (low, medium, high), and the technological complexity into three regions (low, medium, high), yielding a total of 9 (3x3) β cells. A greater degree of analysis is possible by simply dividing the various structural variables into a larger number of regions. Once again, the cells emanating from the two IS structural variables can be clustered for simplification and ease of understanding. In Table 1 we look at the combination of the knowledge complexity variable with the technological complexity variable. By taking the diagonal combinations we generate a continuum for the information systems complexity variable: low (low knowledge complexity x low technological complexity), moderate (medium knowledge complexity x moderate technological complexity), and high (high knowledge complexity x high technological complexity). If a greater detail in the framework is required, other cells can be combined with the respective IS structural variables. Next, we will describe the various cells starting with low knowledge complexity and low technological complexity (β cell 1,1) (see Table 1). Such systems generally revolve around transaction processing and can be conducted manually. For example, a census taker would simply use a notebook to tabulate the number of individuals per household. As the technological complexity increases (β cell 1,2) a centralized computer can be used to process the data. Today, with increasing technological complexity (β cell 1,3) handheld wireless devices could provide census takers to distributed databases and processing of information that has low knowledge complexity.

**Table 1:** Grouping of knowledge complexity and technological complexity into information systems complexity variable (β cells).

| | | Technological complexity<br>Low | Medium | High |
|---|---|---|---|---|
| Knowledge complexity | High | β(3,1) e.g. writing research reports in R&D institutes | β (3,2) e.g. mathematical models to optimize flow of goods on railway lines | β (3,3) High information systems complexity. e.g. Intelligent distributed system |
| | Medium | β (2,1) e.g. voter registration by election commission | β (2,2) Moderate information systems complexity e.g. management information systems in agricultural ministry | β (2,3) e.g. state driver licenses distributed processing and storage |
| | Low | β (1,1) Low information systems complexity e.g. census taker tabulating on a notepad | β (1,2) e.g. centralized transactional processing by census agency | β (1,3) e.g. census taken with wireless handheld device |

As we move to a moderately complex knowledge task (β cell 2,1) such as voter registration, data needs to be collected frequently with a transient and growing population. In more technologically complex systems the use of Management Information Systems (MIS) becomes more prominent (β cell 2,2). For example, the agricultural ministry would be able to analyses and generate reports created on a mainframe or PC and distribute them to various other stakeholders. Today, state agencies (β cell 2,3) might employ the Internet to execute e-commerce transactions. The data may be processed/analyzed at various locations. The common platform of the Internet and the processing/database capabilities of a distributed system make it possible. As the level of knowledge complexity increases, as in the case of R&D institutes, operations can be conducted with relatively low levels of technological complexity (β cell 3,1) by simply employing human experts to write up technical reports. As the technological complexity increases (3,2) information based mathematical models can be used to optimize the flow of goods over the railway lines. Perhaps the task with the highest degree of knowledge complexity and technological complexity has yet to be developed (β cell 3,3). The prescriptive element of this model indicates that such a system would incorporate aspects of learning with distributed processing and databases available on an Internet-like platform. Next, we will combine the information systems complexity variable with the environmental uncertainty variable.

***Process Variables for Operational Information Systems Tasks***

By combining the information systems complexity variable with the environmental uncertainty variable, we are able to define the process variable for operational information systems tasks. Given the three conditions for the information systems and environmental uncertainty variables, we can define nine λ cells (3α x 3β) to define the domain of the operational information systems task variable. Table 2 provides a classification of the domain. The combination of these two variables can define the information system tasks. Thus, tracking sales of stamps on a note pad at a post office would fit under a low level of environmental uncertainty with a low level of information systems complexity would fit in λ cell 1,1. As the level of information systems complexity increases (λ cell 1,2), we might see the aggregation of stamps sales data by locality, region, and state. The Intelligent tracking of stamps and distributed distribution of services (yet to be developed) would be categorized into λ cell 1,3 with a high level of information complexity but a low level of environmental uncertainty. Under conditions of moderate environmental uncertainty with a low level of information systems complexity, tasks such as the renewal of driver licenses can be classified into λ cell 2,1. Where as, the aggregation and distribution of high school state exams results would be classified into λ cell 2,2. With highly complex information systems, the utilization of AI forecasting to forecast literacy rates by district for the respective states would be classified within λ cell 2,3. High levels of environmental uncertainty with low levels of information systems complexity (λ cell 3,1) could simply involve a government official providing directions to disaster victims. Examples of more complex information systems complexity include the use of supply chain management software to manage stocks for a disaster relief agency (λ cell 3,2). Finally, the intelligent tracking of distributed distribution of supplies (yet to be developed) by the government disaster relief agency would be classified in λ cell 3,3 with a high level of environmental uncertainty and high degree of information systems complexity.

**Table 2:** Classification of information systems tasks (λ cells).

| | | **Information systems complexity** | | |
|---|---|---|---|---|
| | | **Low β (1,1)** | **Medium β (2,2)** | **High β (3,3)** |
| Environmental uncertainty | High α (3,3,3) e.g. disaster relief agency | λ (3,1) Providing directions to health care workers on the ground by disaster relief officials. | λ (3,2) Supply chain management software to manage stocks by disaster relief agency. | λ (3,3) Intelligent tracking of distributed distribution of supplies by the government disaster relief agency. |
| | Medium α (2,2,2) e.g. state agency | λ (2,1) Renewal of driver license. | λ (2,2) Collations and distribution of high school state exams results. | λ (2,3) AI forecasting to forecast literacy rates by district. |
| | Low α (1,1,1) e.g. postal system | λ (1,1) Tracking sales of stamps on a note pad. | λ (1,2) Aggregation of stamps sales data by locality, region, & state. | λ (1,3) Intelligent tracking of stamps and distributed distribution of services. |

Next, we will discuss how this typology can be of use to researchers and practitioners.

## 4. Discussion and Conclusion

The existing literature is unclear about the variables that influence the effectiveness of e-governance information systems. This paper attempts to fill this gap in the literature by developing a typology that is a step toward building an integrated theory of information systems tasks; the model specifies the possible relationships between environmental uncertainty and information systems complexity. Providing separate conceptualizations and definitions of knowledge complexity and technological complexity makes it possible to examine combinations and interactions among those variables and to develop more specific predictions about their effect on information systems tasks. The existing literature suggests the need for such clarification, particularly if theory is to more accurately reflect the complexity of most formal organizations.

As the model is operationalized and empirically tested, information systems tasks may be able to be more usefully categorized than in previous typologies. As seen by the current literature, there is a need for typologies based on relational criteria that take into account both information systems complexity and environmental uncertainty. The typology presented in this paper is an attempt in this direction. In this research we bring theory building methodology to develop an e-governance framework, thus providing the field with a typology that has the necessary precision (prediction) and power (understanding), and is relatively parsimonious. The framework developed in this paper attempts to provide the necessary precision (prediction) and understanding (power) of information systems task complexity. This framework is also generalizable to a variety of environmental conditions, agency characteristics and technological capabilities. For example, operations in developing countries would generally fit under the low category of information technology complexity. As countries develop and can support more complex information technologies, they will be able to efficiently accommodate other tasks such as ERP systems.

One direct application of this framework is in project risk assessment. Kumar and Best (2006) provide an example of an initially successful e-government project that became a failure because the "project proved to be politically and institutionally unsustainable due to people, management and structural factors." (p11) Hence, it is crucial to assess and understand risk before implementation. In evaluating the funding or structuring of an e-governance project, government officials who evaluate the project with respect to each of the factors presented in the framework will be more aware of factors related to risk. In such assessments, projects being executed within environments of limited munificence, and a high degree of volatility and complexity will be associated with larger risks. In addition, project based upon more complex knowledge and technology will be associated with higher risk levels. In deciding among a portfolio of projects to execute, additional risks need to be compensated with higher expected returns. Hence, an investment into a project to provide intelligent tracking of distribution of supplies by a government disaster relief agency ($\lambda$ 3,3) needs to balanced with additional financial saving and better services to its citizenry to compensate for greater risk levels.

Government officials can also benefit from this framework in evaluating what may be needed to promote economic growth. Many developing and Newly Industrialized Countries (NIC) countries are eyeing to replicate Silicon Valley in their backyards. To be successful, however, they need to examine the properties necessary for a high degree of technological complexity, such as multiple platforms, diverse technologies, high level of database intensity, distributed database location, diverse information sources, and distributed processor locations. Hence, governments need to provide the necessary telecommunications infrastructure to support these requirements. Finally, this model can be generalized to a range of current technologies and some that are yet to be developed. For example, systems are yet to be developed that allow for a high degree of knowledge and technological complexity. From our typology, we can predict that such systems would have the following properties: multiple breadths of domain, high rate of change of domain(s), expert level depth of domain, extensive systems outputs, range of information inputs, high degree of ambiguity in information inputs, high degree of information interdependence with outside organizations, a high degree of uncertainty associated with information inputs, multiple platforms, diverse technologies, high level of database intensity, distributed database location, diverse information sources, and distributed processor location. Given that the properties of these systems have been defined, researchers and government leaders might want to investigate how such e-governance can be further developed.

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