

# SSME: Services

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Supporting presentation: SSME Systems.ppt

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## Presentation Notes

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The presentation paired with systems module is considered to be supplemental and provide a general context around the notion of general systems and service systems. Materials can be used as a stand-alone introductory topic or supplement to individual topics.

### Slide 1: Systems

#### Systems

This module focuses on the general description of systems and their relevance to services. Services can be viewed as socio-technological systems and differ somewhat from a manufacturing system or economic system. All three systems include elements, interconnections, attributes, and stakeholders. These components can be represented by an input, throughput, output process model where, in a services system there is a feedback loop that defines a service engagement. The service engagement is characterized by client and provider interactions that create value for all parties as a co-productive relationship. This co-productive relationship is what differentiates a service system form other socio-technological systems. General system characteristics and the notion of a service system are explored in this topic.

### Slide 2: Objectives

#### Objectives

1. Start to view services as a system and discuss what that means
2. Articulate key differentiator in a services system
3. Identify and articulate co-production membership
4. Understand how value is defined for a service system

## Slide 3: What is a System?

What is a system?

- **Premise of General Systems Theory**  
*“there exist models, principles, and laws that apply to generalized systems or their subclasses, irrespective of their particular kind, the nature of their component elements, and the relations or ‘forces’ between them”* (von Bertalanffy)
- **A way of looking at and understanding the world**
  - Perception or understanding of a phenomena
  - Construct to simplify complexity
  - Simplification results in assumption that only certain objects, attributes, or interactions are important

In the most general sense, a system is a set of objects, along with the relationships between the objects and between the object attributes; and these objects can be tangible or intangible in nature (Hall & Fagen, 1956). According to Weinberg (1975), a system is a way of looking at the world, it is a point-of-view based on the perception or understanding of a phenomena by one or several observers. This perceived assemblage of interrelated objects comprise a unified whole to facilitate the flow of resources (e.g., information, matter, or energy). The term “system” is often used as a descriptor that defines a set of entities for which a mathematical model can often be constructed to characterize interactions (Wikipedia, 2005).

However, according to Weinberg, it should be noted that in modeling a system there tends to be the assumption that only certain objects, attributes, or interactions are important. “The general systems movement attempts to aid thinking about medium number systems by finding general laws. Although these laws are stated informally to aid recall and initial understanding, an essential part of the general systems approach is the insistence that they are supportable, if necessary, by rigorous operations on rigorously defined models” (p. 28).

This section explore the definition of a system under the premise of General Systems Theory, which assumes that “there exist models, principles, and laws that apply to generalized systems or their subclasses, irrespective of their particular kind, the nature of their component elements, and the relations or ‘forces’ between them” (von Bertalanffy, p. 32).

## Slide 4: System Characteristics

- **The goal is to find the hidden pattern in apparent chaos**
- **A system is any set of available variables selected by an observer to identify fundamental objects, the influential attributes of the objects, and the relationships of these objects that result in a phenomena**
- **Basic assumptions**
  - **Objects can be tangible or intangible**
  - **Objects have attributes**
  - **There are relationships amongst the objects**
  - **There are relationships amongst the object attributes**

How a system is defined depends on the observer’s point-of-view. However, the goal in defining a system, whether the system is natural or artificial, is to examine the phenomena to identify what is “commonplace” or to simplify complexity—to find pattern hidden in apparent chaos (Simon, 1996).

Ashby (1960), provides some general elements that aid in defining a system based on the comparison of the human brain (a type of natural system) and machines (a type of manufactured system). In general, Ashby hypothesizes that “a system can be both mechanistic in nature and yet produce behaviour that is adaptive.” However, to support this hypothesis he makes the assumption that the system being defined is dynamic. That is, the system may change with time.

In addition, the concepts presented herein do not speak to any particular or specialized system such as a living cell or automobile manufacturing process, but are presented to inform of systems in general.

As stated, a system is a collection of objects, object attributes, and relationships between and within objects, and the objects and relationship of interest is dependent upon the perception of the observer. In other words, the objects can be considered to be individual parts that relate to each other to make-up a system. An observer may be interested in the behavior of individual parts in order to assess the larger system. Assessment is made through the identification of both part and system variables. Where, “a variable is a measurable quantity which at every instance has a definite numerical value” (Ashby, p. 14). However, only a subset of all the known variables is of interest for the purpose of assessment. The system itself is “then defined as any set of variables that the observer selects from those available...” (p. 16). This section explores a superset of characteristics that help to identify and define a system.

### Slide 5: System Examples

Type	Description	Key Characteristic	Examples
Natural Systems	Biological, geological, or climatological phenomena that occur in the natural world	Constitutionally organic	Animal Earthquake Weather
Manufactured Systems	Designed creations or artifacts of living beings	Having designed subsystems defined as components, parts, or assemblies	Automobile Computer House
Socio-technological Systems	Combination of natural and manufactured systems	Interaction elements between sociological and mechanical aspects	Business Government Service

To provide some context of system characteristics and general examples, three types of systems are described for comparison in this section.

Natural systems refers to biological, geological, or climatological systems that occur in the natural world. We mention these systems to make note of the fact that the general notion of systems is not confined to artifacts, or systems that are created by human beings.

- Generic examples of biological systems include ecosystems, organisms, and cells.
- From the point-of-view of the organism, we can look at subsystems and supersystems.
  - Subsystems of an organism are of two basic types: systemic parts, such as the nervous system, circulatory system, or the skeletal system; and segmental parts, such as the arm, the torso, or the brain.<sup>1</sup> These segmental parts include aspects of various systemic parts, such that the brain intersects with the circulatory and nervous systems.
  - Supersystems of an organism might include an ecosystem or niche that the type of organism occupies. It may also include a colony, pack, or such group of organisms of the same species.
- Human beings can be seen as natural systems in this sense of being organisms. Humans have similar kinds of subsystems as all other biological organisms. However, they (we) have a much richer set of social supersystems within which we can operate.

Manufactured systems are artifacts, or designed creations of human beings. We might even think of similar systems created by non-human organisms, such as bee hives or beaver dams. A manufactured system (for example, an automobile) in this sense is not to be confused with a manufacturing system (an automotive assembly plant).

<sup>1</sup> This language of segmental and systemic parts is borrowed from D.A. Cruse (1986, p. 169).

- A key aspect of manufactured systems is that they are designed systems, whereas the natural systems above are not primarily designed by human beings. In the age of genetic engineering, of course, this distinction is breaking down in the realm of designer crops and other organisms. However, this distinction due to advances in science and technology are beyond the scope of this topic and are not considered in this discussion.
- An example of a manufactured system would be a railroad car. This system would have components, parts, assemblies, etc. There are both systemic and segmental parts for manufactured systems as well as biological systems. Things like seats, compartments, and wheels are generally segmental, while things like electrical systems, hydraulic systems, and fames are more systemic.
- The supersystem of the railroad car could be seen as the transportation system of a national economy. Another supersystem is the railroad company that owns the car.

Socio-technological systems essentially combine aspects of natural and manufactured or designed systems. Human social systems never exit without support and interpenetration of artifacts and affordances of various kinds. And likewise, the design and manufacture of mechanical systems and other artifacts is always a function of humans working together in various kinds of social systems.

- Businesses and other enterprises are both designed and natural. This is a challenge for the understanding of enterprises, including services enterprises, because the human aspect creates limits on the absolute ability to design the system as a whole.
- Human social systems constitute a major class of the kinds of systems that are called complex adaptive systems. They have the ability to adapt to various changing conditions, and the challenge is to balance adaptation with the proper level of control and standardization.
- The viewpoint of the observer is an important factor here (as noted by the earlier Weinberg and Ashby references). If the observer sees an enterprise as a purely manufacturing concern, the result is similar to the Model-T (one option off the assembly line). One the other hand, car manufacturing today is increasingly being reconceptualized from the point-of-view of an observer who expects to see a service enterprise. Manufacturers are attempting more and more to remain in contact with the customer and providing continuous service through animate and inanimate elements.
- Perception of a system, regardless of type, is dependent upon the observer and what is being measured or quantified—if elements of interaction between the social and mechanical aspects are ignored or unidentified, there may be missed opportunities from the co-production perspective and the idea of providing a service value for both the business and the client.

## **Slide 6: Service System**

### **Socio-technological System**

**Any number of elements, interconnections, attributes, and stakeholders interacting to satisfy the request of known client and create value**

### **Combination of natural and manufactured aspects**

**Humans, Processes, and Goods**

### **Interaction elements between sociological and mechanical aspects**

**Customization activity**

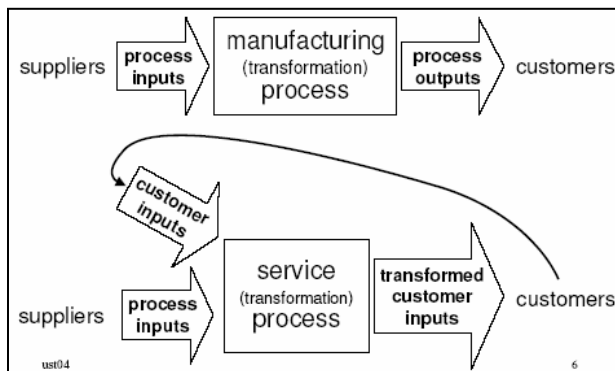
**Co-productive interaction between the provider and client**

**Economic transaction and creation of value**

A type of socio-technological system of particular interest in this topic is the notion of a service system. Subsystems within the service system include both systemic parts such as processes, transformation, and segmental parts such as clients, suppliers, and employees which reside within a supersystem such as an organization, economy, or governance. The idea of a Service System is explored in more detail in the following sections.

A service system is any number of elements, interconnections, attributes, and stakeholders interacting in a co-productive relationship that creates value. As defined by Pine and Gilmore, in general “services are intangible activities customized to the individual request of known clients” (p. 8). This customization activity results in a co-productive relationship which defines a service engagement that is different from other types of economic transactions. Thus, the key characteristic that differentiates a service system model from a traditional economic transaction system model is the interaction with the clients as participants in the service process (Fitzsimmons & Fitzsimmons, 2006; Sampson, 2001). Service system model perspectives of Scott E. Sampson and the team of James A. Fitzsimmons and Mona J. Fitzsimmons are presented to illustrate this key characteristic.

## Slide 7: Model of Unified Services Theory



(Sampson, 2004, p. 6)

Sampson’s (2001) perspective: the simplest form of the fundamental business operations model is that of a basic input/output process. Where, suppliers provide inputs into the production process that become consumable outputs for customers. “The objective is to produce outputs with which the customer will ascribe value, and thus express willingness to buy” (2001, p. 16). The customer (or more commonly a segment of customers) may contribute ideas as desires or new requirements. However, these ideas influence the general production and are considered to be an input into the general design. “The customers’ only part in the actual process is to select and consume the output” (2001, p. 16).

An example of this basic input/output process can be seen in consumer electronics. Where, and electronics company, such as Sony or Panasonic, designs and manufacturers a television to then release it in the retail market. Albeit, the manufacturer often leverages a set of customer-driver requirements for product feature development, the customer is not actually engaged in the decision-making, design, or manufacturing process in this transaction.

Sampson’s (2004) Model of Unified Services Theory figure illustrates the difference between a traditional economic transaction model and a service engagement model. Where, a traditional economic transaction model (e.g., manufacturing process) is provided in the upper portion of the diagram, and a service engagement model (e.g., travel reservation process) is the lower portion of the diagram.

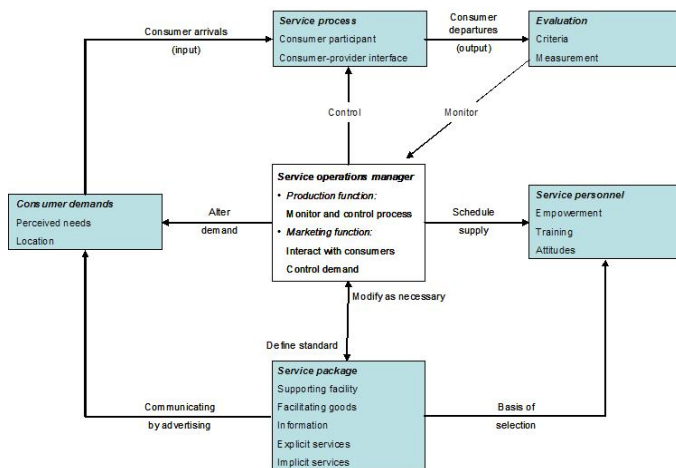
The primary differentiation factor between the traditional economic transaction model and the service system model is that in the service system model the customer (i.e., client or consumer) provides inputs into the process itself. That is, regardless of whether the customer is a business client or an individual consumer, the customer provides essential inputs into the production process to co-create (with the supplier) the final output.

*With services, the customer provides significant inputs into the production process. With manufacturing, groups of customers may contribute ideas to the design of the product, however, individual customers' only part in the actual process is to select and consume the output. Nearly all other managerial themes unique to services are founded in this distinction (Sampson, 2001).*

The transformation process “involves the creation of value in terms of time, place, information, entertainment, exchange, or form utility. The objective of the transformation process is to create an output for a particular customer or market segment that the customer values...” (Collier & Evans, 2005, p. 18). In addition, the transformation process should be considered an integration point for all aspects of operations in creating and delivering services through the creation of value chains. Where, a value chain is “a network of facilities and processes that describes the flow of goods, services, information, and financial transactions from suppliers through the facilities and processes that create goods and services and deliver them to customers” (p. 42).

Final output may be tangible (e.g., customized bicycle or customized code to enable an interface for client-dependent needs) or intangible (e.g., information or a business process). In this model, unlike an economic transaction or business operations model, the input of the customer influences a specific unit of production co-created to meet the needs of the individual customer.

## Slide 8: Open-Systems View of Service Operations



Open-Systems View of Service Operations (Fitzsimmons & Fitzsimmons, 2006, p. 30)

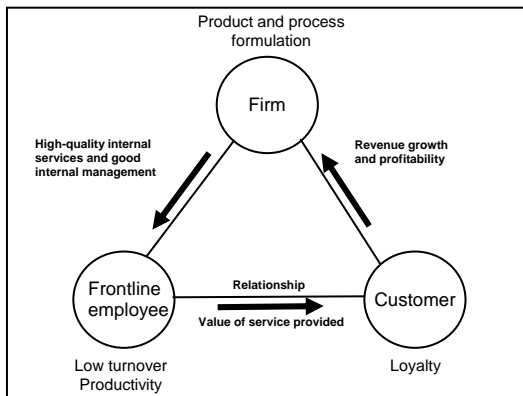
Like Sampson, Fitzsimmons and Fitzsimmons (2006) state that customers are participants in the service system. However, they go on to claim that within the service system “...inputs are the customers themselves, and resources are the facilitating goods, employee labor, and capital at the command of the service manager” (p. 21).

*Service organizations are sufficiently unique in their character to require special management approaches that go beyond the simple adaptation of the management techniques found in manufacturing a product. The distinctive characteristics suggest enlarging the system view to include the customer as a participant in the service process” (p. 29).*

In the “open-systems view of service operations” figure, Fitzsimmons and Fitzsimmons provide an illustration where “the customer is viewed as an input that is transformed by the service process into an output with some degree of satisfaction” (p. 29).

Note: Per Fitzsimmons and Fitzsimmons (2006), the distinctive characteristics of the service process are: intangibility, perishability, and simultaneous provision and consumption (pp. 21-25, 32).

## Slide 9: Co-production Membership in a Service Engagement



Service triangle dynamics (Taboul, 2005, p. 36)

A service engagement or encounter is a key characteristic of a service system. This engagement is distinguished by a provider-client interaction that produces value. According to Sampson, this interaction is a required condition for an economic or business transaction to be considered a service business process. He also provides examples of some service businesses and the customer input as follows (2001, p. 17).

<u>Service Business</u>	<u>Inputs from Customers</u>
Accounting	Financial transaction records
Airlines	Selves and baggage
Architecture	Design preferences
Auto repair	Broken car
Banking	Savings, checks
Consulting	Business problems
Custom home building	Lot, colors and styles
Delivery	Packages
Dental	Teeth
Education	Mind
Entertainment	Attention
Government	Community issues
Legal services	Legal problems
Medical	Sickness or injuries
Public services	Burning house
Real estate	Property to sell
Restaurant	Empty stomach
Retail	Questions about products

Fitzsimmons and Fitzsimmons (2006) state that both the provider and the client "...have roles to play in transacting the service. ... The customer is participating in the service delivery as a partial employee with a role to play and is following a script that is defined by societal norms or implied by the particular design of the service offered" (p. 206). The implied script that each role follows customarily:

- implicitly (e.g., societal norms) or explicitly (e.g., terms and conditions) defines expectations for both parties for the service engagement,
- provides an element of perceived control in the service engagement, and
- provides a level of behavioral predictability in the service engagement.

*Society has defined specific tasks for service customers to perform, such as the procedure required for cashing checks at a bank. Diners in some restaurants may assume a variety of productive roles, such as assembling their meals and carrying them to the table in a cafeteria, serving themselves at a salad bar, or busing their own tables. In some cases, the customer has learned a set of behaviors that is appropriate for the situation."* (p. 206).

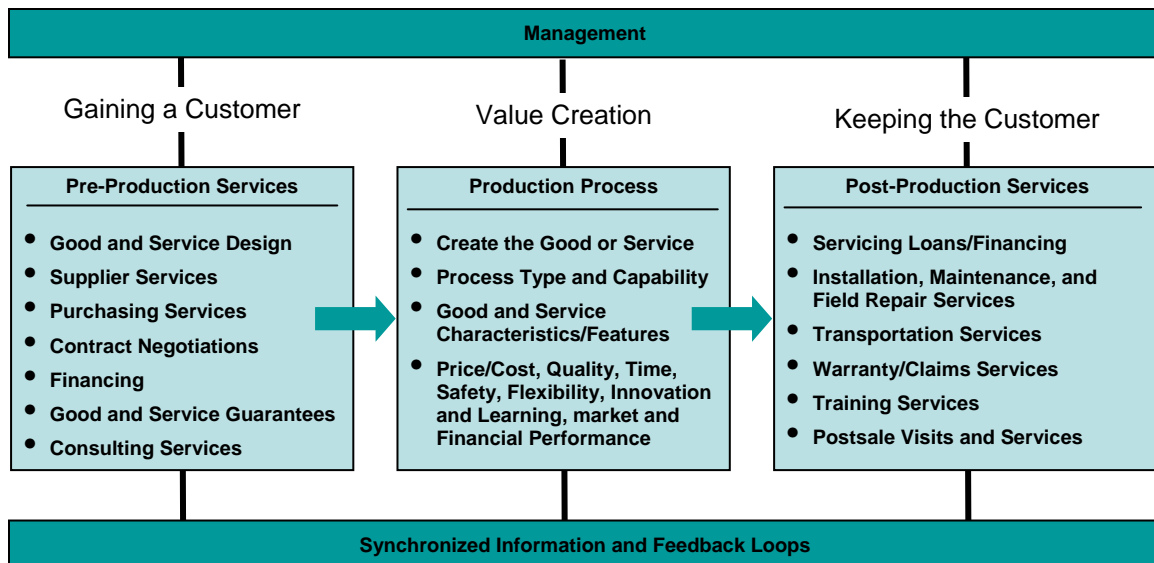
In addition to the general idea of co-production, Fitzsimmons and Fitzsimmons divide service engagements into three different levels where there is evidence of a dominant party in the interaction (pp. 198 - 199):

- Dominated by the Service Organization. Characterized by standardized service delivery (e.g., franchise services)
- Dominated by the Contact Personnel. Characterized by the provider being in the role of expert and the client in the role of subordinate (e.g., physician-patient relationships)
- Dominated by the Customer. Characterized by the client having control over the service engagement, whether it is a standardized service engagement (e.g., banking ATM transaction) or a customized service engagement (e.g., legal counsel).

*A satisfactory and effective service encounter should balance the need for control by all three participants. The organization's need for efficiency to remain economically viable can be satisfied when contact personnel are trained properly and the customer's expectations and role in the delivery process are communicated effectively"* (p. 199).

Fitzsimmons and Fitzsimmons describe this relationship as the service triangle. However, Teboul (2005) provides additional insight into the definition and illustration of the concept as service triangle dynamics. Where the service engagement is often illustrated as "...the company or the firm is placed at the top of the triangle and customers and employees are placed on an equal level. Employees deliver, control and market their services, and clients take part in the production process (co-production), control and may even market the service (by word of mouth)" (p. 24).

## Slide 10: How is Value Created?



Pre- and Post-service View of the Value Chain (Collier & Evans, 2005, p. 45)

Value can often be readily assessed from the provider's perspective (e.g., revenue, reputation, or cost savings) and the client's perspective (e.g., procurement, needs fulfillment, or return on investment) for manufactured goods. However, value can be a little more elusive in a services system. In general, the value from the service engagement within the service system can result from any number of interacting system components or economic entities in support of the engagement. According to Pine and Gilmore, "service providers use goods to perform operations on a particular client (such as haircuts or eye exams) or on his property or possessions (such as lawn care or computer repair). Clients generally value the benefits of services more highly than the goods required to provide them. Services accomplish specific tasks they [clients] want done but don't want to do themselves; goods merely supply the means" (p. 8).

Teboul defines value as "...the result of the comparison between perceived benefits and perceived sacrifices, one obvious sacrifice being the willingness to pay the price" (p. 60). To be more specific, Collier and Evans state that "value is the perception of the benefits associated with a good, service, or bundle of goods and services in relation to what buyers are willing to pay for them. ...One of the simplest functional forms of value is [value = perceived benefits/price (cost) to the customer]" (p. 41). Value is then linked to value chains where success depends on decisions that impact value chain aspects of suppliers, inputs, processes, and output or outcomes. Examples of value chains are illustrated in Collier and Evans' (2005) pre- and post-service view of the value chain figure and examples of goods-producing and service-providing value chains table.

Examples of Goods-producing and Service-providing Value Chains (adapted from Collier and Evans, 2005, p. 44).

Organization	Suppliers	Inputs	Transformation Process	Outputs	Customers and Market Segments
Auto assembly plant	Engine plant Tires Frame Axles Paint Seats	Labor Energy Auto parts Specifications	Welding Machining Assembly Painting	Automobiles Trucks	Economy Luxury Rental Trucking Ambulance Police
Airline	Food manufacturers Fuel and oil Pilot training Security	Planes Labor Baggage Energy Repair parts Knowledge	Plane repair Pilot and plane schedules Baggage service Cabin service Security system	Safe & on-time flight	Economy Luxury Private jet Business classes Cargo Mail
Oil refinery	Oil suppliers Utility companies Pipelines	Crude oil Energy Labor Equipment Specifications	Chemical reaction Separation Distribution	Gasoline Motor oil Fuel oil	Automobile gasoline stations and grades of fuel Retail stores Airplane fuel Home heating oil
Hospital	Pharmaceutical companies Equipment suppliers Food suppliers Organ donors Medical supplies	Patients Beds Staff Drugs Diagnostic equipment Knowledge	Admissions Lab testing Doctor diagnosis Food service Surgery schedules Drug administration Rehabilitation	Healthy people Lab results Accurate bills Community health education	Heart clinics Pediatrics Emergency and trauma services Ambulatory services Medical specialties and hospital wards
Pizza restaurant	Food wholesaler Equipment suppliers High school students	Food raw materials Orders Energy Labor Equipment	Order taking Home delivery In-store service Bill payment Food production	Good pizza Happy customers Quick service	Premium pizza Home delivery In-store seating Discount market Catering and group sales
State government	Highway and building contractors Employment agencies Food suppliers Equipment suppliers Other governments	Labor Energy Information Trash Crimes Disputes Sick people Low-income people	Health care benefits Food stamps Legal services Prisons Trash removal Park services License services Police services Tax services	Good use of taxpayers monies Safety net Security Reallocate taxes Clean, safe, and fun parks	Disabled people Low-income people Criminals and prisons Corporate taxes Boat licenses Building inspections Weekend vacationers Child custody services Legal court services
e-Publishers	Authors Software vendors Research articles Electronic books and readers	Labor Knowledge Software Computer servers Scanners Printers Energy	Internet network Editing text, audio, and video Publisher screening of authors' work (i.e., quality control) Promotion Payment Security	e-books downloaded to PCs and e-book readers Bytes of information and knowledge	Entertainment books Journals and magazines Time-sensitive books such as stock market information Knowledge-based textbooks Reference books Libraries

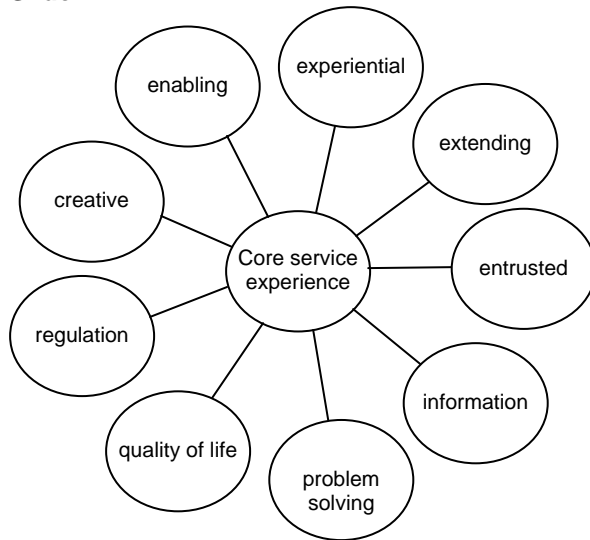
## Slides 11 and 12: Characteristics of Example Emerging Services and Typology of Services

### Slide 11

Example Emerging Services	Service Systems Engineering Characteristics			
	Information-Driven	Customer-Centric	E-Oriented	Productivity-Focused
<b>Wholesale &amp; Retail:</b> Mass Customization	X	X	X	X
<b>Business &amp; Professional:</b> "Early Warning" System	X			X
<b>Education:</b> Internet-Based Distance Learning	X	X	X	X
<b>Government:</b> Crime "Hot Spots"	X			X
<b>Health Care:</b> Medical Triage	X	X	X	X
<b>Finance, Insurance &amp; Real Estate:</b> Internet-Based Auctions	X	X	X	X
<b>Transportation:</b> Airline Passenger Screening	X	X		X
<b>Communications:</b> Real-Time Routing	X	X		X

Service Systems Engineering: Characteristics of Example Services (Tien & Berg, 2003, p. 34).

### Slide 12



Tien and Berg (2003) categorizes service systems by engineering characteristics and provide additional scope of what a service system is as "...all economic activities whose output is not a physical product or construction, is generally consumed at the time it is produced and provides added value in forms (such as convenience, amusement, timeliness, comfort or health) that are essentially intangible..." (p. 18). Implicit in this definition is the recognition that service production and service delivery are an integrated process. Where the "...potential for service systems engineering methods [is to] address the information-driven, customer-centric, e-oriented and productivity-focused issues that are pertinent to services" (p. 33). Slide 11 provides an illustration of service systems engineering characteristics and the value domains they can be associated with.

This potential for service systems is then driven by the co-production experience (e.g., intangibility, options, control, supporting goods and technology) of both the provider and the client. This then provides an introduction for the notion of "reuse". That is, according to Chesbrough

(2004, p. 8), “advances have enabled information that had previously accompanied the production of agricultural or manufactured products to be separated from those artifacts. [Where], the information is not consumed in the exchange, but remains available for additional use or reuse by others.” This reuse of an intangible product creates an additional value created via service systems. Bryson, Daniels, and Warf provide a discussion with regards to the blurring division between service and manufacturing and provide a typology of services that exemplifies a list of service values (Slide 12).

A Typology of Services in the Twenty-first Century Economy (Bryson, Daniels, and Warf, 2004, p. 33).

<b>Core service experience</b>	<b>Commentary</b>
Creative	Incorporate, represent or present ideas that are used to shape production, encourage consumption or interpret culture, identify, etc. (advertising services, design services, art galleries, museums, theatres, film production)
Enabling	Many services act as intermediaries in the sense that they enable other tasks or objectives (telecommunications services, public transport facilities, executive search consultants, employment agencies, contract lawyers)
Experiential	Requires presence of the customer or user who expects to experience something tangible or intangible (ballet or opera performance, massage, haircut, cordon bleu meal at a restaurant, visit to a theme park)
Extending	Tasks intended to extend product life, to maintain reliability, to encourage customer loyalty and repeat transactions (full replacement warranties for specified times or levels of use, other after-sales services, consumer satisfaction services, installation and updating services, ‘health’ checks (people, equipment, products such as certain personal financial services) and follow-on advice)
Entrusted	Undertaken on behalf of customers or clients at their request or as part of a contractual arrangement, usually without the need for the customer to be present (car servicing, watch or camera repair, financial portfolio management, return-to-base warranties)
Information	Decision-making on a wide range of personal and corporate matters is facilitated by access to information; some is freely available, some can be accessed for a fee, some is privileged (news agencies, data mining services, real estate agents, stockbrokers, travel agents, internet search engines, electronic database services, broadcasting)
Innovation	Highly dynamic and rapidly changing as yesterday’s innovations are replaced by today’s innovations (digital interactive sports services, shopping and related services via television, WAP mobile telephone services, research and development services)
Problem solving	Individuals and firms are constantly confronted with financial, management, restructuring, staffing, infrastructure and many other problems. Specialists are often used to address these (management consultants, tax consultants, marriage counseling, Citizens Advice Bureaux, IT consultants, engineering and planning consultants)
Quality of life	Services that reflect availability of increased leisure time, opportunities to counteract illness, or threats to things such as the environment (adults education services, health services, sports and recreation services, tourism services, waste disposal services, security services)
Regulation	Much of the economy (and indeed society) operates within a framework of rules and regulations that apply at all levels ranging from the local to the global (police services, patent agents, legal services, planning services, environmental services)

## Summary

In general, a service system is considered to be an open-system in which the client provides input into the service process. The client as a provider of direct input into the system creates a co-productive relationship with the service provider. Disruptions to the service system can result from rigidity or imbalances in the system. However, if the service system retains an acceptable degree of balance, value in the form of quality of life, security, or prosperity is achieved for both the client and provider.

## Activities

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1. Compare and contrast the Sampson model with the Fitzsimmons' model.
2. Can a service model turn into an economic transaction model or vice versa? If so, how?
3. Discuss (contrast) two of the central factors that impact system balance.
4. Discuss how Bryson, Daniels, and Warf's core service experiences should or should not be considered a service system value.

## References and Additional Readings

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## Systems Addendum

### A Living Systems Model<sup>2</sup>

A starting point to understand the components of system can be demonstrated through a living systems model. James Grier Miller presents a very generic model that illustrates the components of a well-integrated system. Miller, with his living systems model, builds on a school of thought within general systems theory that treats organizations as living entities.<sup>3</sup>

This model, pictured below, provides a pattern of 19 functional subsystems at several levels of complexity. The same sets of subsystems are to be found at the levels of:

- a single living cell
- an organ
- an organism
- a human organization.

Obviously these subsystems do not take the same form at each level of complexity. However, the common abstractions in Miller's model are revealing in terms of the fundamental functions that must be performed by organizations, in much the same way they must be performed by individual organisms.

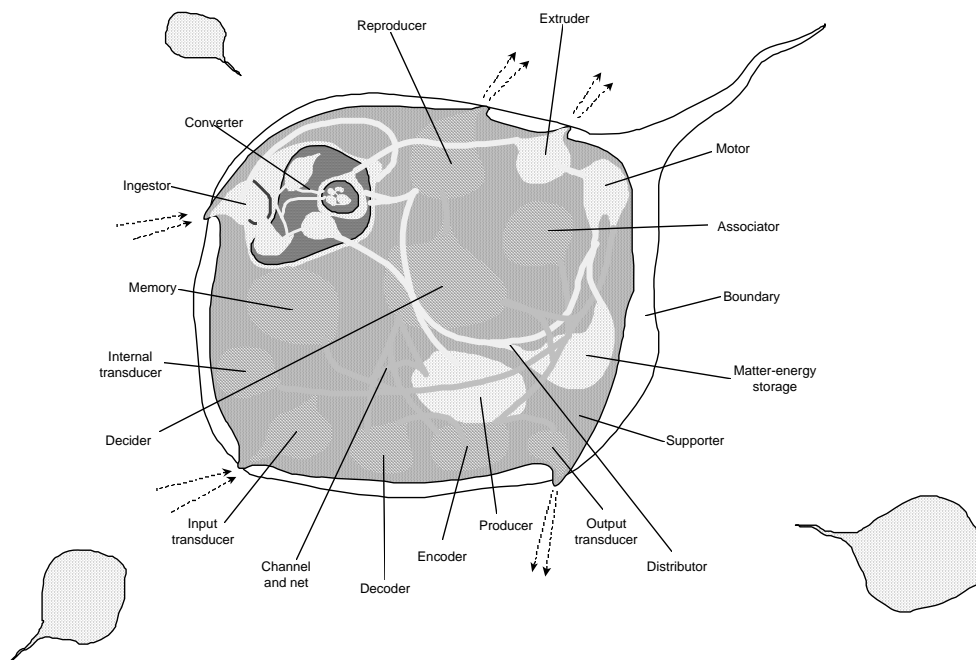


Figure 1. Miller's Living Systems Model.

Miller's 19 domains of functionality are grouped into systemic areas within the organism:

<sup>2</sup> This section is adapted from McDavid, 1998.

<sup>3</sup> Miller, 1978

**Material and energy subsystems** are the functions within the organization that process material, use energy, and produce products and byproducts:

1. Ingestor - brings material and energy resources into the system
2. Converter - transforms material and energy from one form into another
3. Motor - provides impetus for all forms of motion
4. Distributor - moves material and energy around in the system
5. Supporter - provides physical scaffolding for the system
6. Matter and energy storage - stores energy and material for use by the system
7. Producer - produces the primary product of the system
8. Extruder - sends forth products and byproducts of the system into the environment

**Information processing subsystems** are the nervous systems of organisms and organizations:

9. Memory - stores and recalls information for later use
10. Encoder - transforms of raw information input into internal encoded form
11. Decoder - transforms encoded information into externally understandable form
12. Associator - interrelates information within the system
13. Decider - makes decisions on behalf of the system
14. Channel and net - moves information from place to place
15. Input transducer - amplifies or damps incoming information signals
16. Internal transducer - amplifies or dampens internal information signals
17. Output transducer - amplifies or dampens outgoing information signals

**Hybrid subsystems** have both material and information management aspects:

18. Boundary - provides protective functions and structures
19. Reproducer - produces new systems (organisms or organizations).

Although designed to better understand and interpret the intricacies of a living organism, Miller's 19 domains within a living systems model can help us to understand functions within an organization. All of the subsystems need to be created and maintained by information systems professionals from within and without the respective companies. However, the relative importance of these various subsystems and their actual forms will differ based on the role of the business.

This model sheds light on the role or purpose of an organization within society. This role of the enterprise has profound implications for information systems. For instance a telecommunications company, as part of the channel and net function of society, has much greater emphasis on particular kinds of information and information systems than does a toy manufacturer, which is primarily a producer kind of organization.


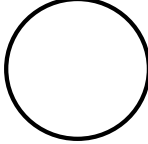


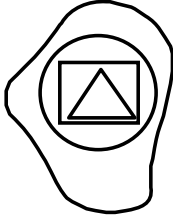
#### **A Viable Systems Model<sup>4</sup>**

This section introduces a simple, powerful pattern of functionality. The Viable Systems Model (VSM) is a very rich view of the enterprise, which also views the enterprise as a set of generic domains. Unlike the Miller model, it is strictly focused on domains that deal with information and communication. The theory of organizations as viable systems was originally articulated by

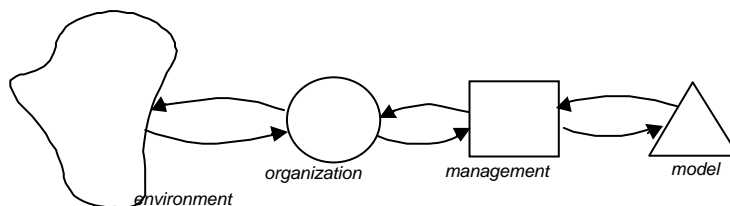
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<sup>4</sup> This section is adapted from McDavid (1998).

Stafford Beer and is summarized in an accessible form by Barry Clemson<sup>5</sup>. According to this model, every viable system, from a bee colony to a nation, follows a template of management and operational functions, along with standard types of communication channels. This template is defined as follows.

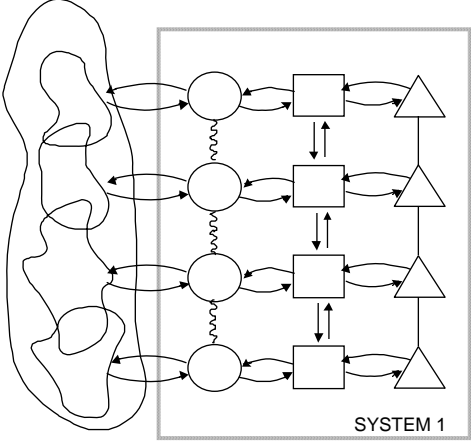
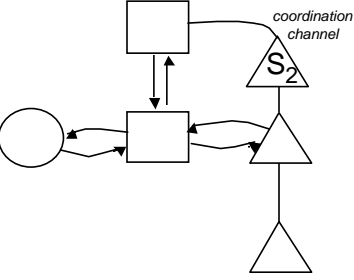
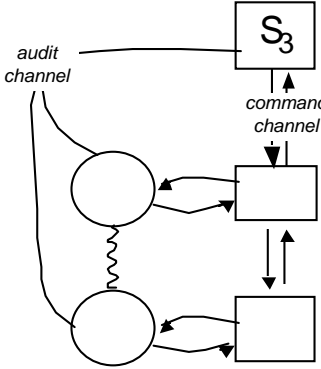
<p>Every organization (viable system) exists within some environment. This is the symbol for the environment.</p>	
<p>An organization is represented by a circle.</p>	
<p>Within every viable organization there exists some management function, represented by the square.</p>	
<p>The management function is accomplished according to a model, often not explicitly recognized, but necessarily present.</p>	
<p>These elements are clearly nested, with model within management, within the organization, within the environment. This in itself creates a containment relationship.</p>	

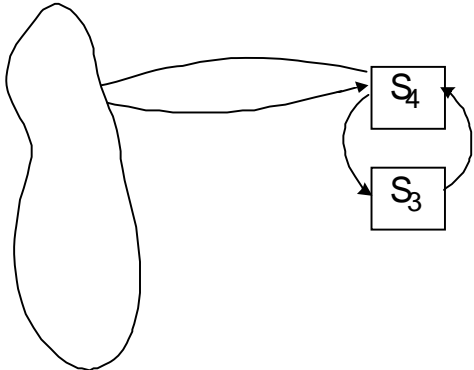
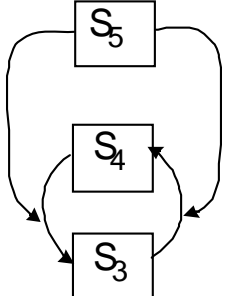
Even though these elements are nested as shown above, the VSM is largely concerned with channels for information. In order to emphasize these communication channels, we can imagine the elements outside of the containment relationship, are linked together.



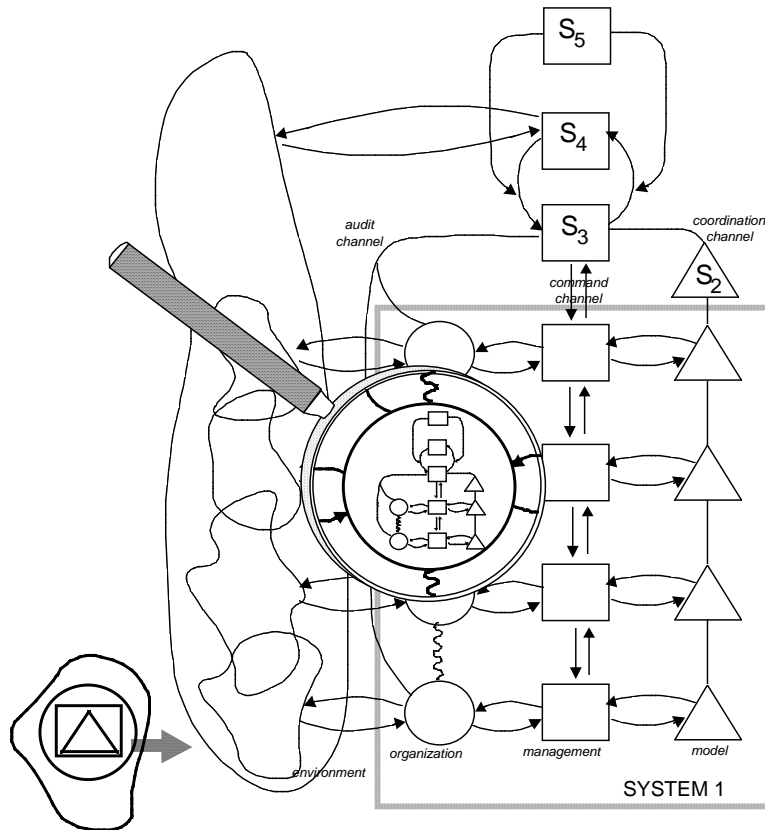
<sup>5</sup>Clemson, 1984

This configuration of one organization, with its environment and its management structure, forms an operational unit. This is the level where the basic functions of the organization are accomplished. The fact is, though, that most organizations we deal with have many operational units, each with its own management, and dealing with a different, possibly overlapping, part of the environment.

<p>The separate operating units can be structured according to functional principles, geography, or on the basis of the particular type of product that they produce. Each operating unit is responsible for producing the primary results (products and services) that are the reason the organization exists.</p> <p>The collection of interacting operating units, minus the environment, is what the VSM calls System 1. The information systems needs implied by System 1 include the ability to measure productivity, cost per units produced, customer and supplier information, shop floor control, inventory management, etc.</p>	
<p>System 2 is responsible for maintaining and coordinating the set of mental management models (including standard practices and forms) within the organization as a whole. System 2 functions constitute "the way we do things around here". System 2 has responsibility for many of the information resources of the organization, including automated systems. Normative information such as human resource practices, business forms and the like are the province of this domain.</p>	
<p>System 3 uses a direct command channel to give orders to the operating units via their individual management structures. It also uses an audit channel in its responsibility for the day-to-day, bottom-line processes of System 1's activities. The information requirements for System 3 include clear and timely instructions to the operating units, and timely, accurate responses back from those units. There is a need to filter the information noise of day-to-day operational activity, while amplifying the feedback on key measures.</p>	

<p>In contrast to System 3, System 4 is responsible for looking outward into the environment as a whole, and as much as possible into the future. It is the part of the organization that is oriented toward learning and change. As such, its dealings with System 3 are somewhat adversarial—the difference between a future-oriented and a here-and-now perspective. The information system needs of System 4 include good receptors of external intelligence, market demographics, competitive information and the like. System 4 also needs good information processing, or analytical support to be able to make sense of masses of data and to determine key indicators and trends.</p>	
<p>In order to mediate between the current and future needs of the organization there is a System 5, which ideally consists of the most senior management. The information requirements for System 5 are not well served by current automation capability, given that the primary need is to exert judgment, and reconcile proposals put forth by Systems 3 and 4.</p>	

Putting the whole model together, we can see that the viable systems model is a recursive, or fractal structure. Inside every operational element of the organization we see a recapitulation of the entire model, Systems 1 through 5, behaving at a more microcosmic level.



Both the VSM and Miller's living systems model are completely generic with respect to all types of organizations, in all industries and sectors of the economy. In the living systems and the viable systems models we are introduced to generic patterns that describe the fundamental nature of organizations. As can be surmised, these patterns give rise to the idea of domains. This discussion has been in the spirit of looking for domains that we can map to business system architectures.

In the same spirit, we now turn briefly inward to look at the domains of concern within human cognition that can help articulate the idea of patterns (of cognitive functionality). The articulation of patterns allows us to explore or define the thought process that must be present to allow organizations formulate and pursue effective strategies. Is there a model that can help us get a better handle on this? The next system architecture aids in understanding just this question.

### A Cognitive System Architecture

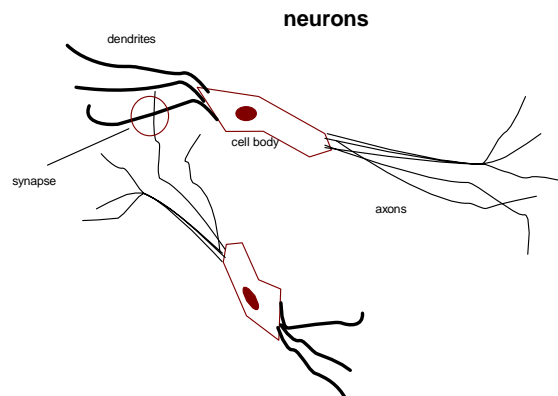
The seat of human cognition is the nervous system, with a highly developed brain. There is evidence that this nervous system is very much a web or network of interacting components and processes. Marvin Minsky<sup>6</sup> talks about an organization of very simple mental agents, each of which has limited intelligence, but which form increasingly complex patterns of interaction. Each agent, starting from the most primitive sensing mechanism, must perform its specialized work correctly. Relationships among these agents must be maintained and continue to evolve through the maturing and learning process.

<sup>6</sup>Minsky (1985)

Arnold Trehub<sup>7</sup> proposes a possible architecture of the physical brain, to account for basic human cognitive capabilities. These human cognitive functions include the following, from the simplest to the most complex:

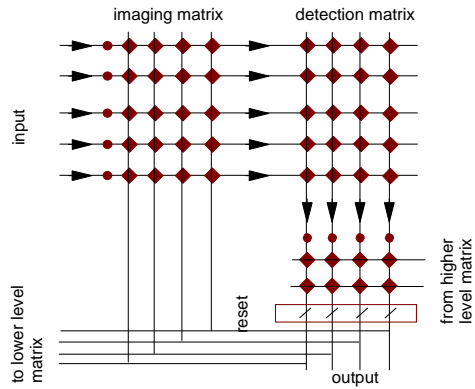
1. Parse an object or a part of an object as a stimulus entity when presented with any arbitrary object or an arrangement of objects (a scene).
2. Represent the relative location of any parsed object in a three-dimensional viewer-centered space.
3. See an object or a scene on at least one occasion and recognize it later despite substantial changes in object size, angular orientation, or position in space.
4. Search for and locate an object that has been learned if it is present in a complex scene.
5. Reconstruct an approximate image of an object or image that has been learned when it is absent.
6. Construct and learn new images by combining parts of objects and scenes recalled from its learned repertoire (memory).
7. Recognize learned patterns despite inputs that are substantially incomplete or degraded by noise.
8. Disambiguate the stimulus and sequentially recognize the constituent patterns if the model is presented with a complex pattern composed by the superposition of previously learned patterns.
9. Detect, learn, and recall spatial relationships among objects in a scene.
10. Respond, given any arbitrary input pattern, with a series of recognition indicants and their associated images recalled from its learned repertoire, which are ordered in output according to some measure of pattern similarity with the arbitrary stimulus.
11. Learn substantial sequences of visual input and later accurately recall at least parts of the image content of selected sequences in correct temporal order.
12. Learn and recall a name for each entity it has learned.
13. Organize and relate its internal representations as equivalents to subject and predicate in a propositional structure.
14. Generate sequences of related inferences, a substantial proportion of which are logically true within the terms of a complex propositional structure.
15. Image, or otherwise recall, if the model is presented with a name, its representation of the object, entity, characteristic, or relationship that the name stands for.
16. Control its behavior in accordance with its motivational needs.
17. Attach some indicant of value to any current or imaged environment (scene) or episode according to the degree to which it meets its motivational needs.
18. Plan, execute, and learn sequences of its own behavior that lead to environments or episodes that meet its motivational needs.

Trehub proposes an architecture of the brain that can support these cognitive capabilities that are observable within human beings. Complexity emerges from the interaction of simple parts. Chemical reactions enhance and inhibit the ability of the neurons to build up and release electric charges in binary, on/off voltage spikes. Starting from the physiology of the neuron, with synaptic junctions among axons and dendrites, a mechanism is proposed that can perform various cognitive tasks.

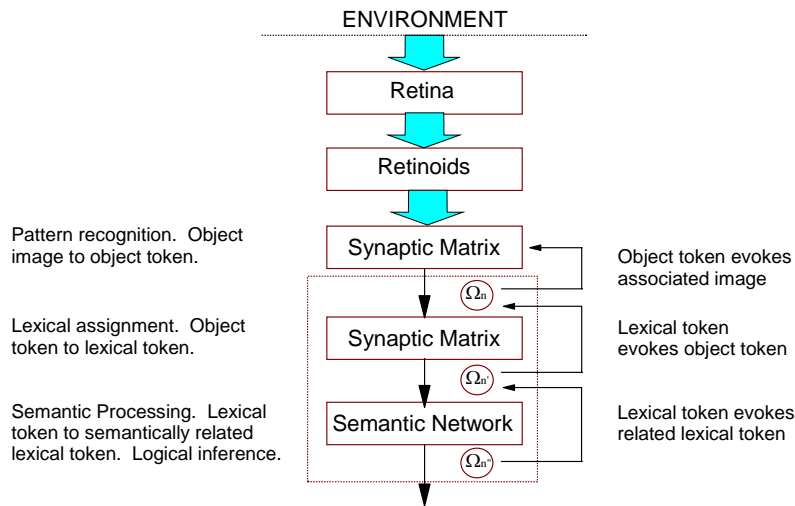


Trehub postulates matrices of synapses that work together to build up higher levels of functionality. The figure below is part of the mechanism that processes visual input. There is a domain of imaging functionality, and a domain of detection. These need to work together, and then report up to higher levels of cognitive functionality in order to process information acquired through the visual modality.

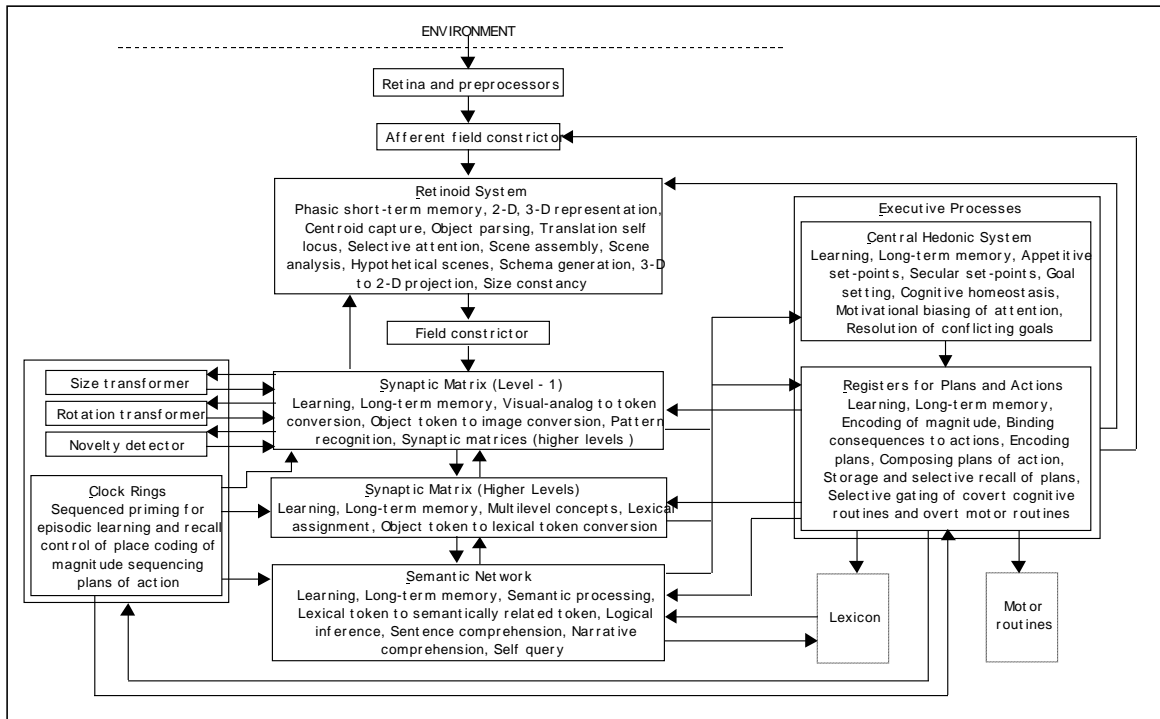
<sup>7</sup>Trehub (1991)



The next figure is a simple block diagram showing levels of visual image processing domains. From the time light enters the retina until logical inferences can be drawn, there are succeeding higher levels of processing domains that are invoked. Each has a high degree of specialization, but they all must work together to draw even the simplest conclusion from environmental stimuli, such as “This is the interviewing manager. I should shake hands.”



The following figure is Trehub's block diagram of a more complete cognitive architecture. The components include synaptic matrices, simple input preprocessors, clock rings, size and rotation transformers, a semantic network, and various high-level executive processes, such as registers for plans and actions.



Note the resemblance of the block diagrams that Trehub draws to the kinds of drawings made by technologists when explaining the intricacies of information systems architectures. This cognitive architecture serves as a further model for how we can attack the issue of a generic architectural framework of business domains.

### A Socio-Technological Model<sup>8</sup>

The following section presents a domain architecture that can be applied to any business, any enterprise, indeed any human organization. It draws on patterns that we have previously reviewed - the living systems model, the viable systems model, the cognitive architecture of the human brain. This is a business pattern of the most generic kind. It is composed of a set of domains of functionality which can serve as a template for constructing Porter style strategic activity systems. We borrow the term “domain” from the terminology of IT architecture, where it is “a subject area which can be described separately from other aspects of an IT system (e.g. work flow, user interface behavior, transactionality are domains).” A well-known example of a set of domains in the IT world is “the ISO-OSI 7-layer model, in which each level defines a domain addressing a well-specified subset of the overall problem area.”<sup>9</sup>

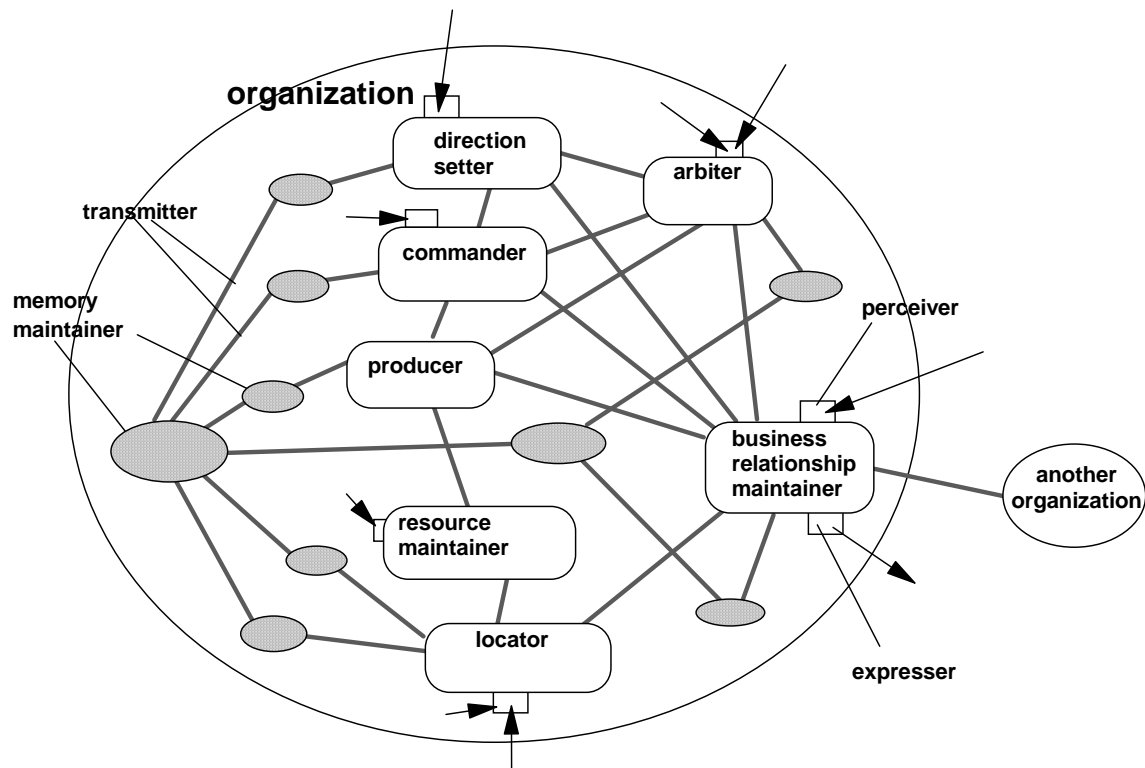
This is very much in keeping with the message that Christopher Alexander delivered to OOPSLA in 1996, when he addressed the assembled programmers with a bit of bemusement about why they would be interested in a person who had spent his life designing buildings, but nevertheless challenged them to adopt “a view of programming as the natural genetic infrastructure of a living world.”<sup>10</sup>

<sup>8</sup> This section is adapted from McDavid, 1998

<sup>9</sup> Kahan, et al, 1998

<sup>10</sup> Alexander, 1996

We start with an overview. The high-level domains that are depicted below bring together elements from the models we have discussed earlier. There is a boundary around the organization, and there are information processing domains, very similar to several of the subsystems in Miller's living systems model and the domains of the Viable Systems Model. These are limited, single-function homunculi, and as such are all expressed as active entities, or performers<sup>11</sup>. Each one is a socio-technological subsystem in its own right, potentially containing both human beings and computing technology. Clearly, to the extent that people exist in these functional domains, they are using only a small subset of their capabilities at any given time. This means that people in each of the domains move in and out of roles, as the situation warrants.



There are *perceivers* and *expressers* that communicate with the world outside the business or other organization of interest. There are *transmitters* that move information around. Note that the *memory maintainer* is a highly distributed function. The *direction setter* detects changes and trends in the environment, and makes high-level decisions about the strategy of the organization. The *commander* domain is analogous to System 3 in the viable systems model, and organizes the operational units, such as the *producer* and its *resource maintainer* to carry out the strategy. Maintain internal and external relationships is fundamental to the organizational type of system, so we have called out a specific *business relationship maintainer* domain. The *arbiter* is very much like VSM's System 2, in terms of setting norms and rules of behavior.

Each of the domains in the preceding figure is further analyzed and defined in the sections below. There is a recursive aspect to this architecture that mirrors the same kind of recursiveness in the living and viable systems models. This is reflected in the fact that each of the domains shown can contain instances of other domains at an arbitrary level of nesting. Also, keep in mind that

<sup>11</sup>Pincker, 1997

there are people and technology at all levels, and throughout all the domains of this structure.  
This is a socio-technological system.