Applying Systems-Thinking for Business Analytics

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Today's Agenda

Part One

Introduction to Systems Thinking and Analytics

Business Analytics

Systems

Systems Thinking

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Business Analytics

Analytics Defined

Analytics: The application of logic, analysis, and mental processes to improve understanding of something that is of interest. The understanding may be related to past, present, or future behaviors of or to relationships within the thing of interest.

TDWI Introduction to Business Analytics

Analysis: Understanding how a complex system behaves and the reasons for its behavior; systematically decomposing a system into its parts to identify the parts and understand the relationships and interactions among them.

TDWI Introduction to Business Analytics

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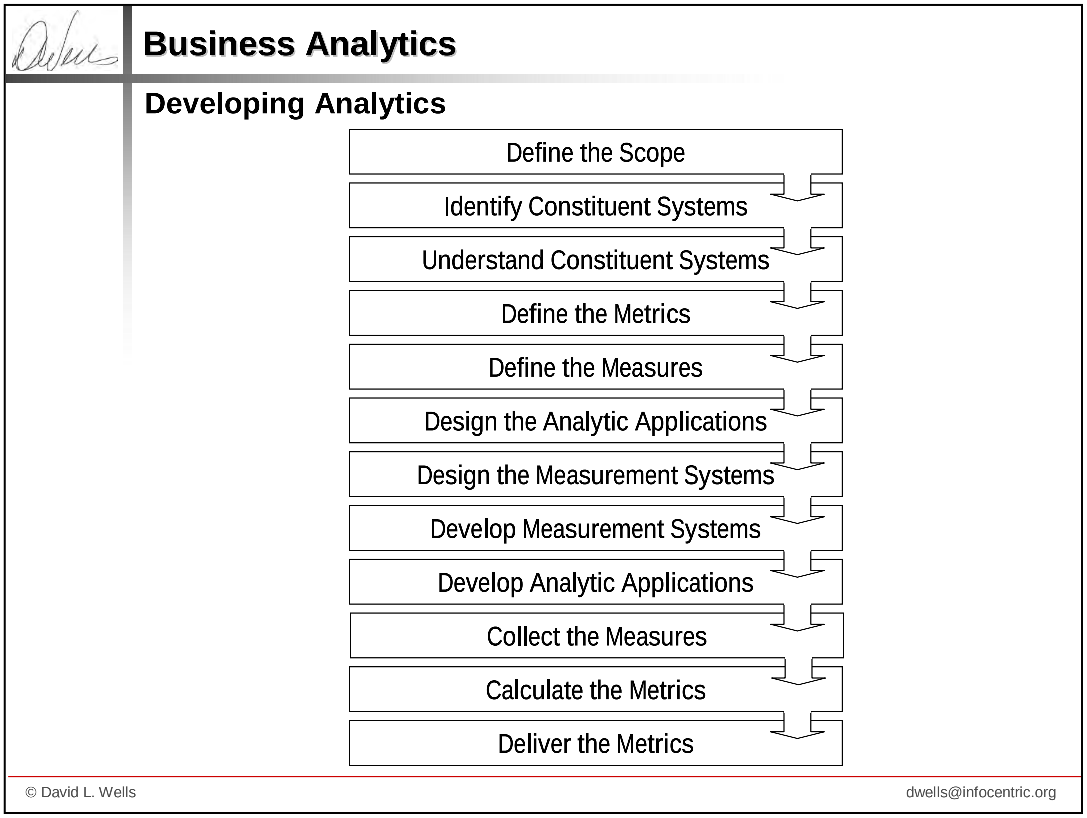
- **Analytics:** The slide above shows the TDWI definition of analytics. The key words in this definition are logic, analysis, mental processes**,** and understanding*.*

- **Mental Processes:** The very important implication of this phrase is that business analytics and business intelligence are people processes. Bob Duniway, CIO at Seattle University, expresses it this way: *"Business intelligence doesn't happen in BI tools. It happens in the minds of people and in the conversations that take place between those people."*

- **Analysis:** The slide also shows the TDWI definition of analysis – a term used in the definition of analytics. This definition includes three concepts that are directly related to the principles of systems thinking – system behaviors, parts of a system, and interactions among the parts.



- **Scope:** Every development project begins with scope – defining the boundaries of the project in terms of what it will and will not produce.

- **Constituent Systems:** Analytics development begins with knowledge of the systems that are within the scope of the development effort. The interest here is very specifically in business systems, not computer systems. Determine which systems are to be measured, then analyze those systems to understand the parts and the interactions among them.

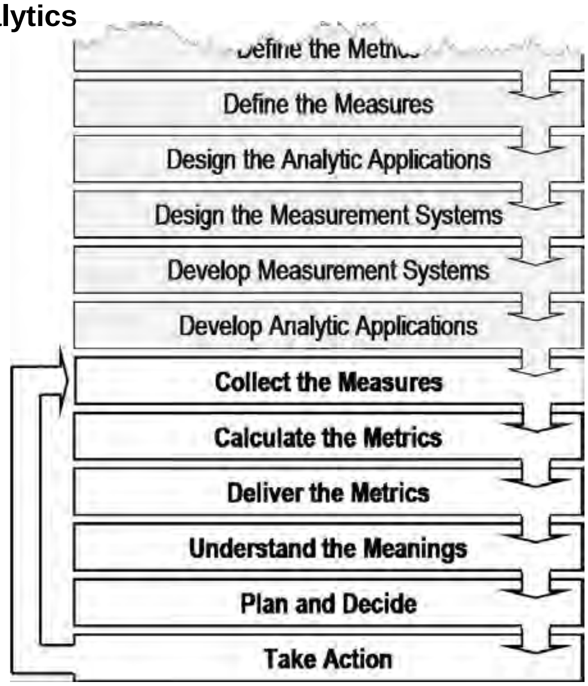
- **Metrics and Measures** are the components that quantify characteristics of the business systems of interest. Measures are discrete data values at a point in time. Metrics aggregate measures, adding business context, comparative context, and dimensionality.

- **Measurement Systems** are those systems that collect and store measures. They may exist in the form of operational systems and data warehouses, or they may require that new systems be put in place to capture measurement data.

- **Analytic Systems** are those systems that aggregate measures into metrics, present them in graphical, tabular, or other formats, and provide end-user capabilities for access and analysis.

Business Analytics

Using Analytics



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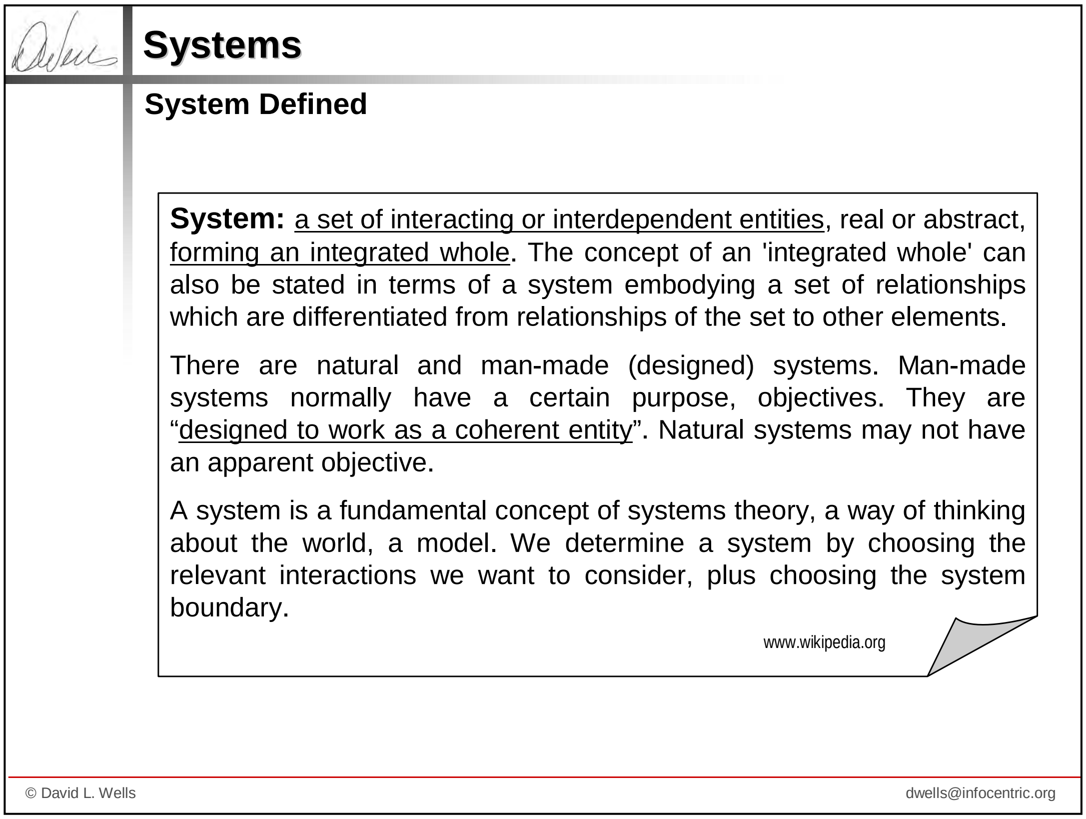
- **Analytics and Technology:** Analytic usage depends on technology to produce usable metrics, tables, graphs, scorecards, dashboards, etc. This is the area where development and usage overlap. Collecting measures, calculating metrics, and delivering those metrics are both development activities and continuous through the life of an analytic system. Note that usable is not the same as useful – one of the reasons that systems thinking is an important addition to the analytics developer toolkit.

- **Analytics and People:** Simple delivery of useful metrics does not create intelligence in the business. Business intelligence occurs when people examine the metrics to determine what they mean, to expand knowledge of business behaviors, to plan, to make informed decisions, and to take effective actions.

- **Analytics and Feedback:** Business intelligence isn't complete without a feedback loop. Continuous measurement and regular analysis are the mechanisms by which we know and improve reasoning, planning, forecasts, solutions, and understanding. Peter Senge describes this process as *"the learning organization"* in one of the definitive systems-thinking works –*The Fifth Discipline: The Art and Practice of the Learning Organization.* Measurement-based feedback is also a core concept of Six-Sigma, ISO-9x, TQM, and other continuous improvement practices.

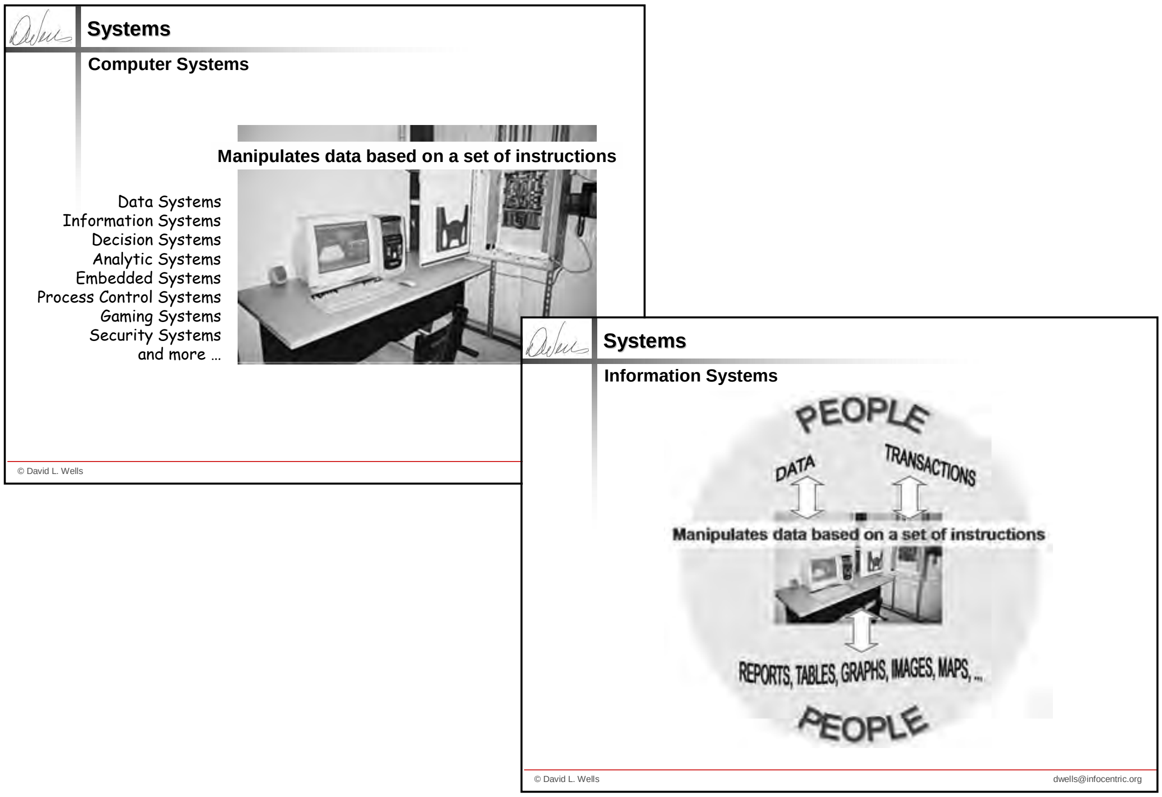


- **Systems Described:** This slide shows parts of the wikipedia description of systems thinking. I refer to this as a “description” and not a “definition” due to the fact that it is lengthy and still somewhat obscure. Some key phrases from the description are useful to understand definition of the term “system”

  ✓ a set of interacting or independent … entities
  ✓ an integrated whole
  ✓ differentiated from relationships to … other elements
  ✓ the system boundary

- **Some Conclusions about Systems:** Considering this description as it relates to many of the systems in my experience – computer, business, social, etc. – I believe the following to be general truths about systems:

  ✓ A system is a collection of interacting parts.
  ✓ Behavior of any part is influenced by interaction with other parts.
  ✓ A system boundary defines the set of parts that comprise a system.
  ✓ A system may interact with things outside of its boundary.
  ✓ External interaction is less influential of system behavior than internal interaction.
  ✓ Behavior is understood by examining the entire system, not individual parts.

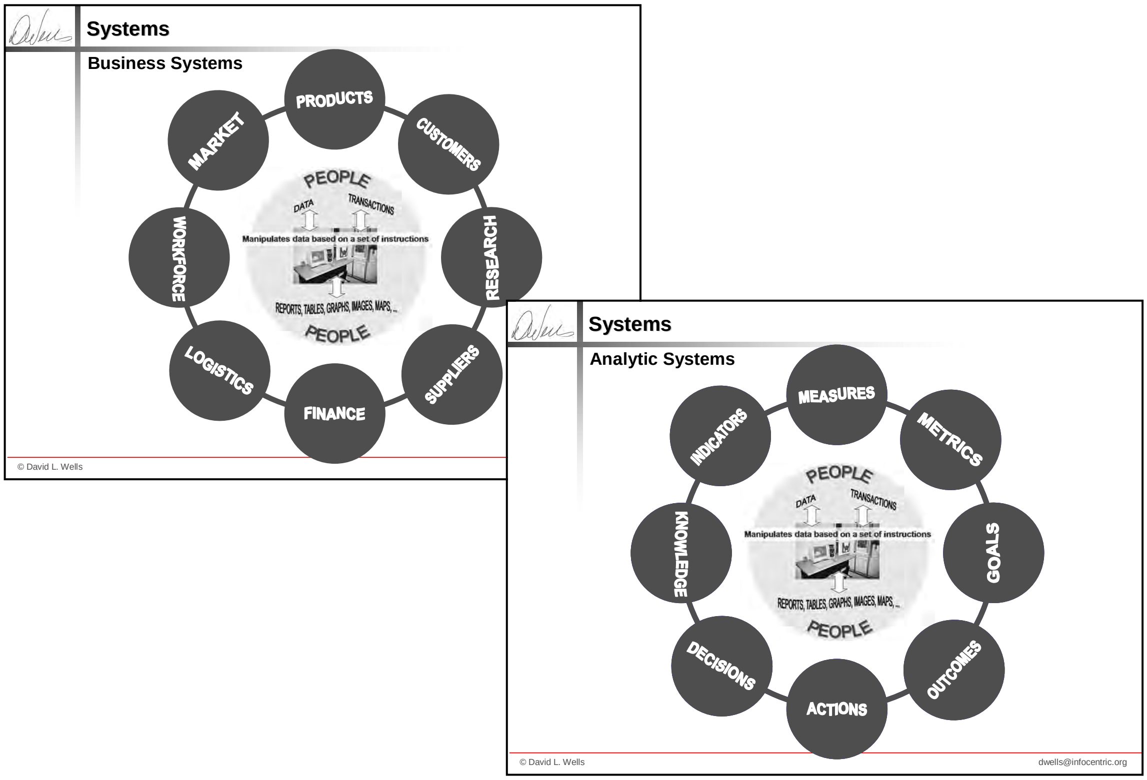


- **Computers and Systems:** Computer Systems are those systems that manipulate data based on a set of instructions. The interacting parts of a computer system include processors, storage, peripheral devices, and operating systems software.

- **Computerized Systems** include many types including data and information systems, decision support, embedded and process control systems, gaming systems, access and security systems, and more. The interacting parts of a computerized system include data and applications software.

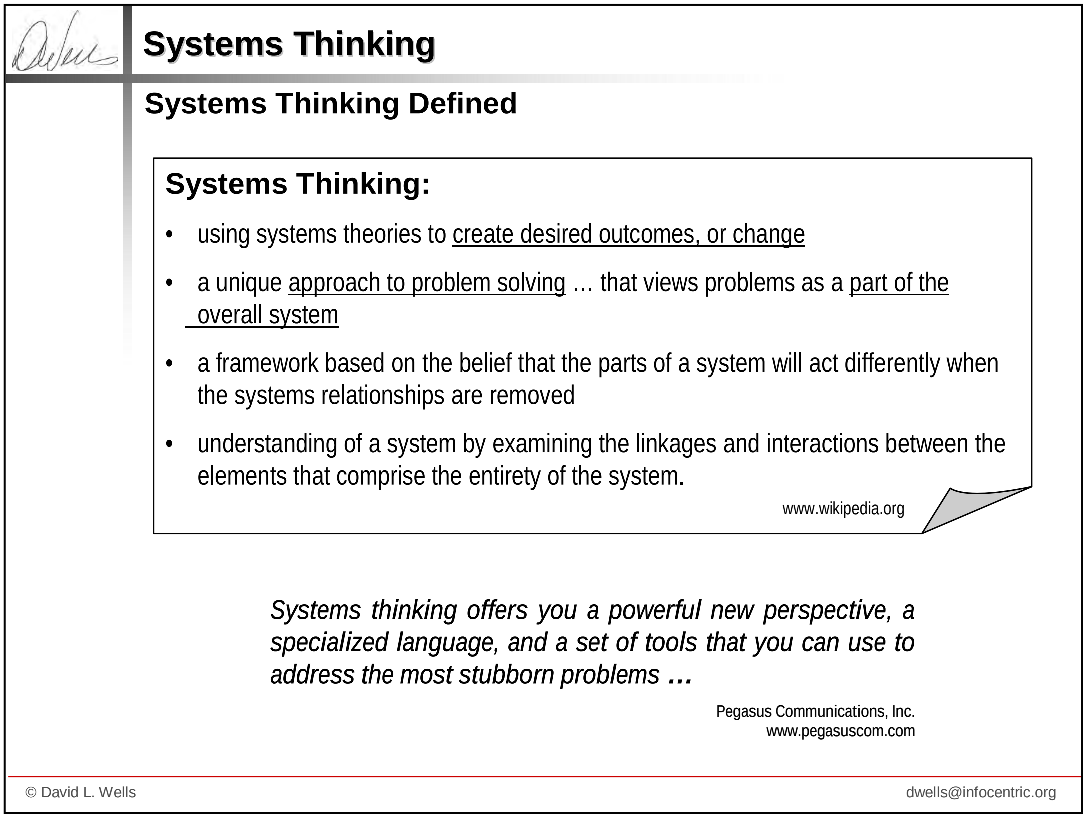
- **Computer Systems Roles:** Computer systems in business are typically parts of larger systems. All too often, we think of the computerized portion of a business system as *"the system"* when in truth it represents only automation of some parts of a system that also includes people, organizations, manual procedures, and much more.

- **Beyond the Computer**, Information Systems include computerized systems but extend to include business transactions, data about transactions, people who conduct transactions, procedures that govern them, transaction-based information in the form or reports, graphs, etc. Information systems also include the people who use information – reports, tables, graphs, images, etc. – that is captured, created, stored, and reported.



- **Conducting the Business:** Reaching beyond Information Systems, business systems encompass the people, processes, and technology that are needed to operate and sustain a business. Business systems include complex interactions among several or all of many business functions such as planning, finance, human resources, marketing, sales, production, customer service, procurement, purchasing, research, development, communication, public relations, and internal audit. Business systems often depend upon information systems which, in turn, depend on computer systems.

- **Measuring the Business:** Analytic Systems work in parallel with business systems – ideally as a part of business systems – with goals of efficiency and effectiveness in how business is conducted. Analytic systems quantify and inform the business, providing the knowledge needed to understand, solve problems, and receive feedback. The parts of an analytic system include indicators (such as KPIs), metrics, measures, goals, decisions, actions, outcomes, and knowledge.



- **Applied Systems Theory:** Systems Thinking is the application of systems theory – the study of Systems Dynamics - to effect change. The systems-thinking approach provides perspective and tools for problem solving, systems modeling, and practical understanding of complex systems.

- **Problem solving** in the systems-thinking approach views problems as part of the overall system. Traditional problem-solving approaches tend to focus on one or a few parts of a system, believing that changes to those parts offers a solution. The systems-thinking approach focuses on interactions and influences as the core elements of solving problems.

- **Systems Modeling** is performed by modeling the parts of a system and the interactions among those parts. Several archetypes – base models that represent common kinds of systemic behaviors – are central to systems modeling.

- **Understanding** of systems is achieved through identification, modeling, and analysis of relationships and interactions among the parts of a system – a distinctly different and more in-depth analysis than is possible with structural models of a system.

Part Two

Systems Thinking Concepts

Systems Thinking Basics

Feedback Loops

System Archetypes

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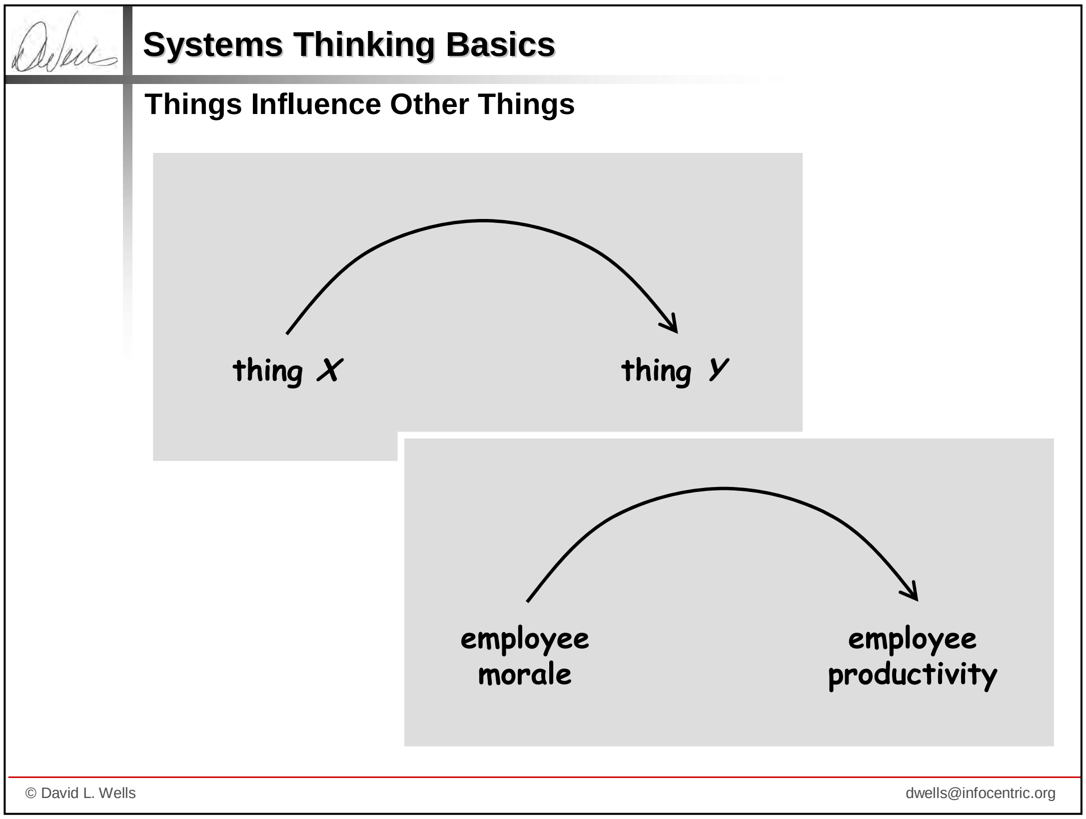


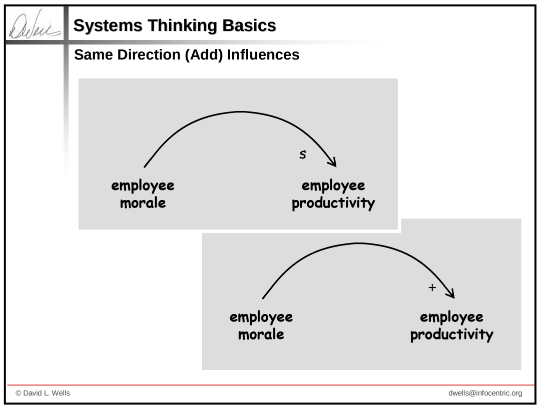
- **The Most Basic Concept** of systems theory is that a system is a collection of interacting things. I use the word thing to avoid the context-based connotations that might occur with terms such as entity, object, or component.

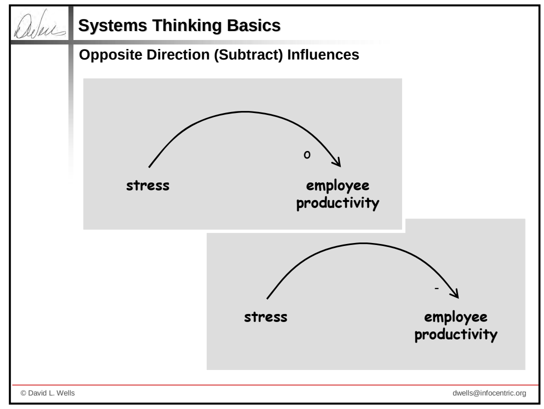
- **Things in a System** are of many types. They may include (but are not limited to) entities that are familiar to data modelers, objects that are familiar to object-oriented systems analysts, and components as understood by software developers.

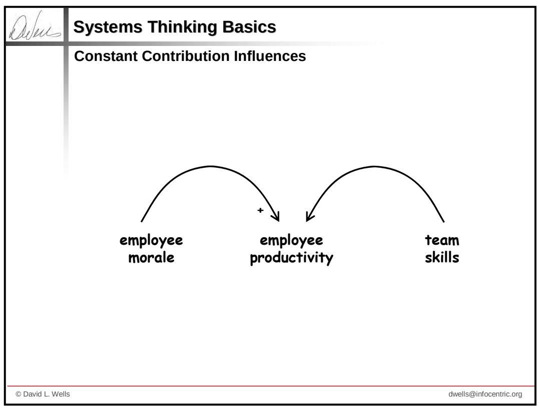
- **Things in a Business System** encompass artifacts such as resources, capacities, limits, gaps, goals, desires, actions, results, plans, processes, rules, standards, and much more.

- **Influence** is a behavioral characteristic of interaction. Interaction between two things in a system is directional – one thing has influence on another thing.

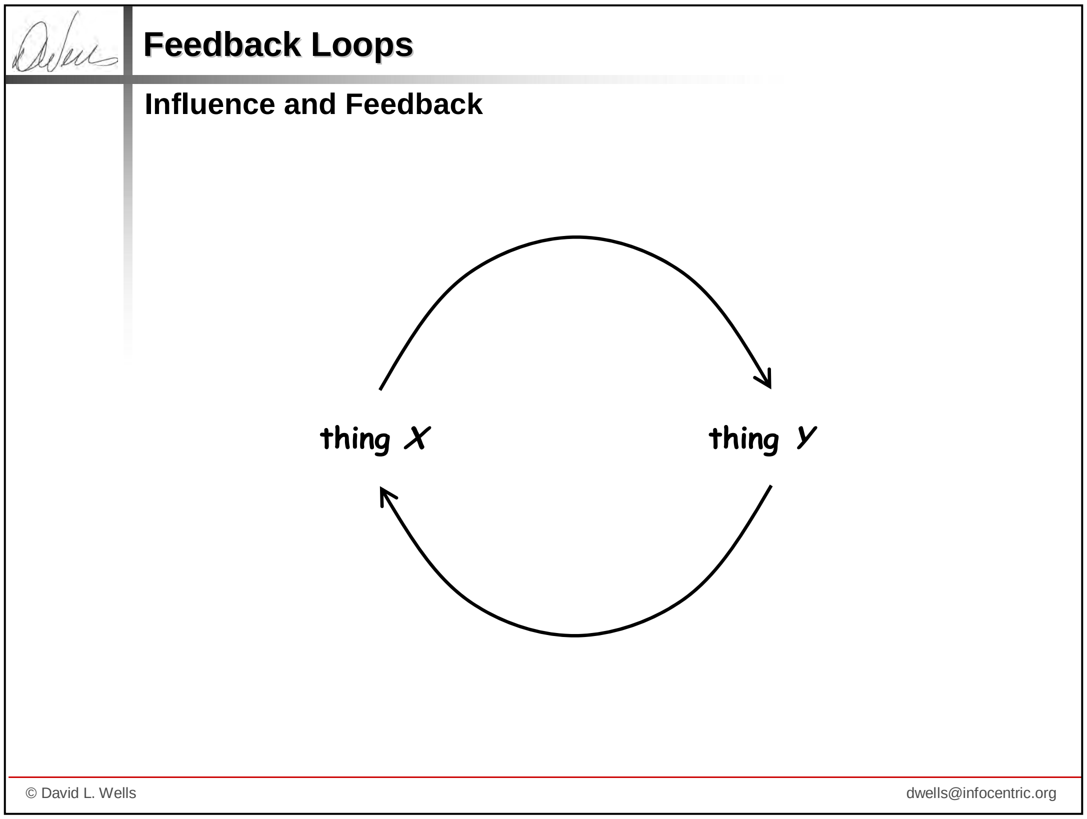
- **System Behavior** is important to understand why things happen in a system, and to predict what may happen in the future. Analysis of influences is the key to understanding system behavior.







- **Same Direction Influence** is one of the behaviors of system interaction. This concept is also called additive influence.
- **System Diagramming Notation** for same direction / add influences is common in two forms – by noting the link between things with "s" meaning "same" or with a "+" meaning "add."
- **Add Isn't Always Good:** The example shows an additive influence of employee morale upon employee productivity. This diagram says that morale and productivity move in the same direction. When morale improves productivity also improves. When morale declines productivity also declines.
- **Opposite Direction Influence** is another of the behaviors of system interaction. This concept is also called subtractive influence.
- **System Diagramming Notation** for opposite direction / subtract influences is common in two forms – by noting the link between things with "o" meaning "opposite" or with a "-" meaning "subtract."
- **Constant Contribution Influence** is a behavior of system interaction that is more difficult to comprehend than add and subtract influences. Constant contribution occurs when a thing remains constant within the scope and context of the system that is the subject of analysis. This concept is also called catalytic influence. It is often used for resources that are important within the system but externally driven.

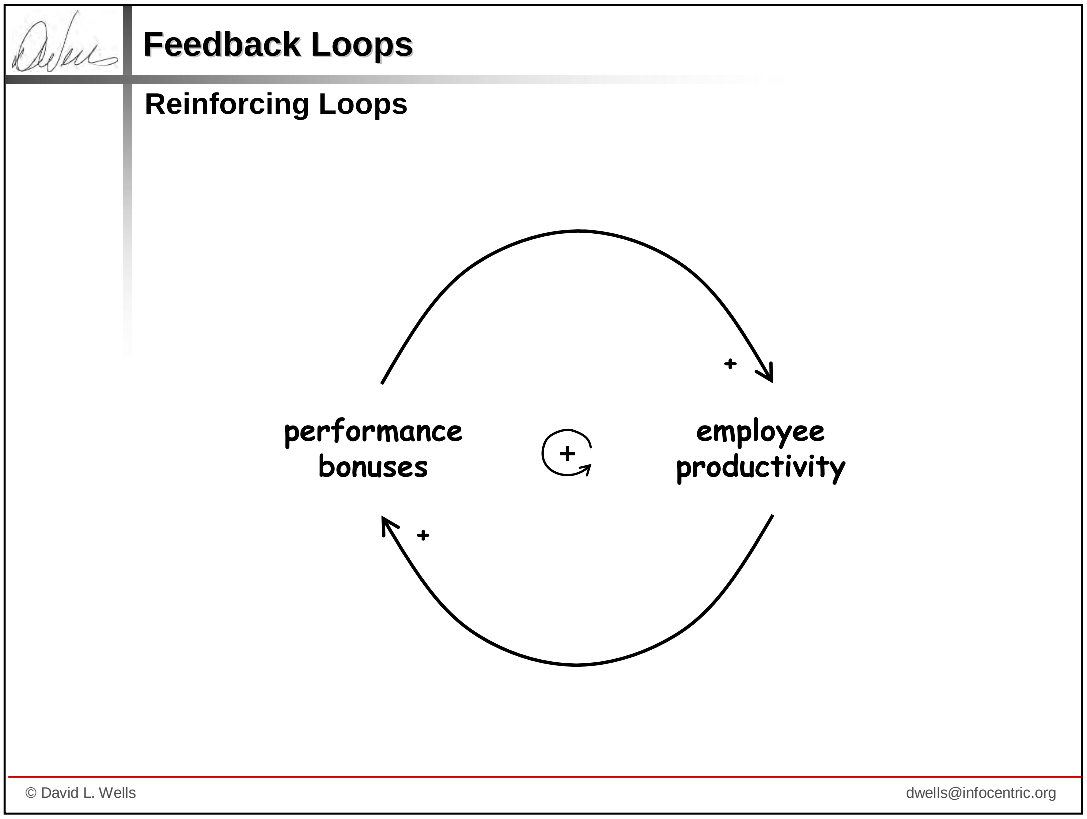


- **Loops** are closed structures that represent a sequence of system interactions without a beginning or an end. A loop may contain any number of interactions greater than one. Feedback is a characteristic of loops in systems.

- **Feedback** is a process by which the results of an activity or action are returned to the actor in a way that influences the behavior of that actor. Positive Feedback occurs when the cumulative effect of all interactions in the loop is one of growth, amplification, or acceleration. Negative Feedback occurs when the cumulative effect of all of the interactions is stabilization or equilibrium. The positive or negative totality of a loop is called loop polarity.

- **Polarity** refers to the positive or negative feedback property of a loop. Positive polarity is sometimes noted by using the symbol at the center of the loop, and negative polarity by using the symbol . An alternative notation uses **R** to denote a reinforcing (positive polarity) loop, and **B** to denote a balancing (negative polarity) loop.

- **Determining Loop Polarity** is relatively easy. Simply count the number of subtractive interactions in the loop. An odd number indicates negative polarity, and an even number positive polarity.



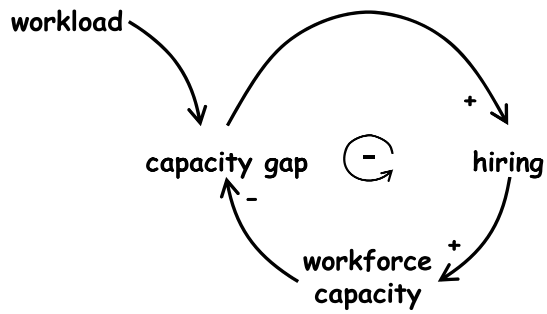
- **Positive Polarity Loops** are known as reinforcing loops. These loops act to amplify the behaviors of the things that interact within the loop. A reinforcing loop “feeds on itself” to produce growth or decline.

- **In the Example** increasing performance bonuses cause increases in productivity, which in turn cause more growth in bonuses. Similarly, decreasing bonuses cause declining productivity, which further diminishes performance bonuses.

  Note that the explanation above does not imply that performance bonuses are the beginning of the loop – there is no beginning or end. The example can be as easily and accurately described as**:** increasing productivity causes increased performance bonuses, which in turn causes greater productivity. Similarly, declining productivity causes smaller bonuses, which further erodes productivity.

Feedback Loops

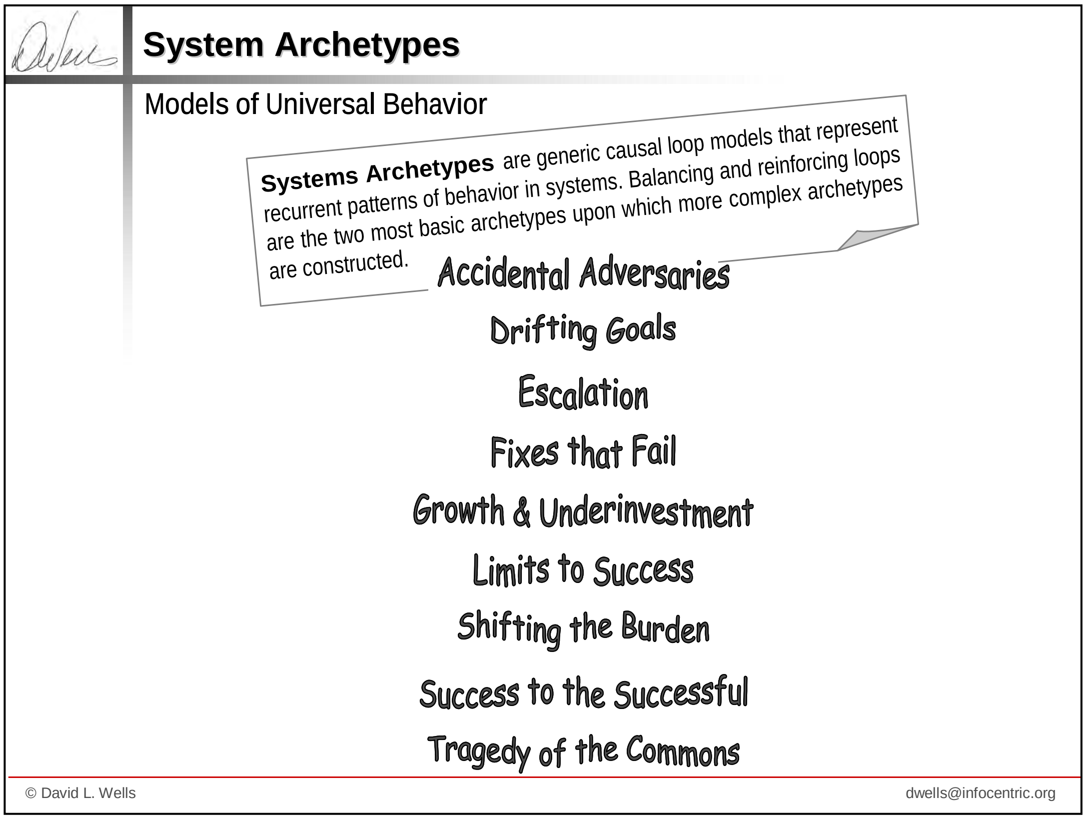
Balancing Loops



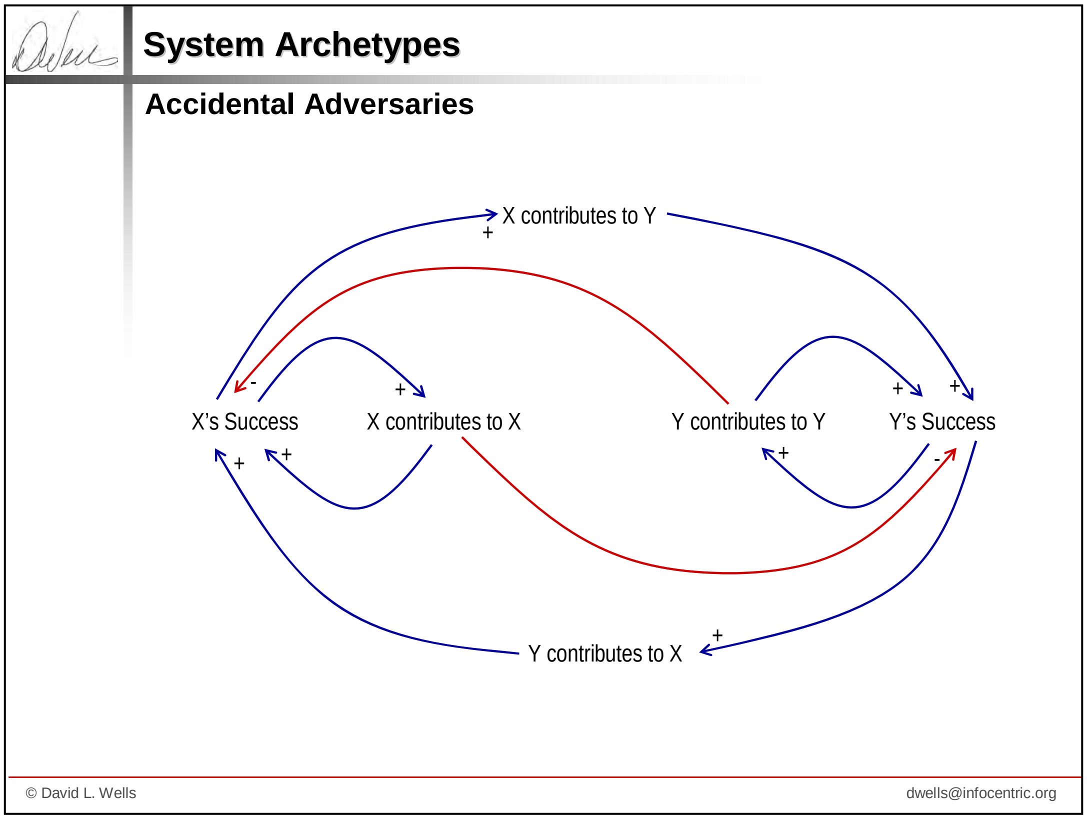
- **Negative Polarity Loops** are known as balancing loops. These loops attempt to bring two things into agreement. They are sometimes referred to as goal-seeking loops.

- **The Things in a Balancing Loop** will assume specific roles. A desired state is established by an external link – the "goal" of goal-seeking. Participating in the loop are things that represent the current state, the gap between desired and current states, and the action which seeks to close the gap.

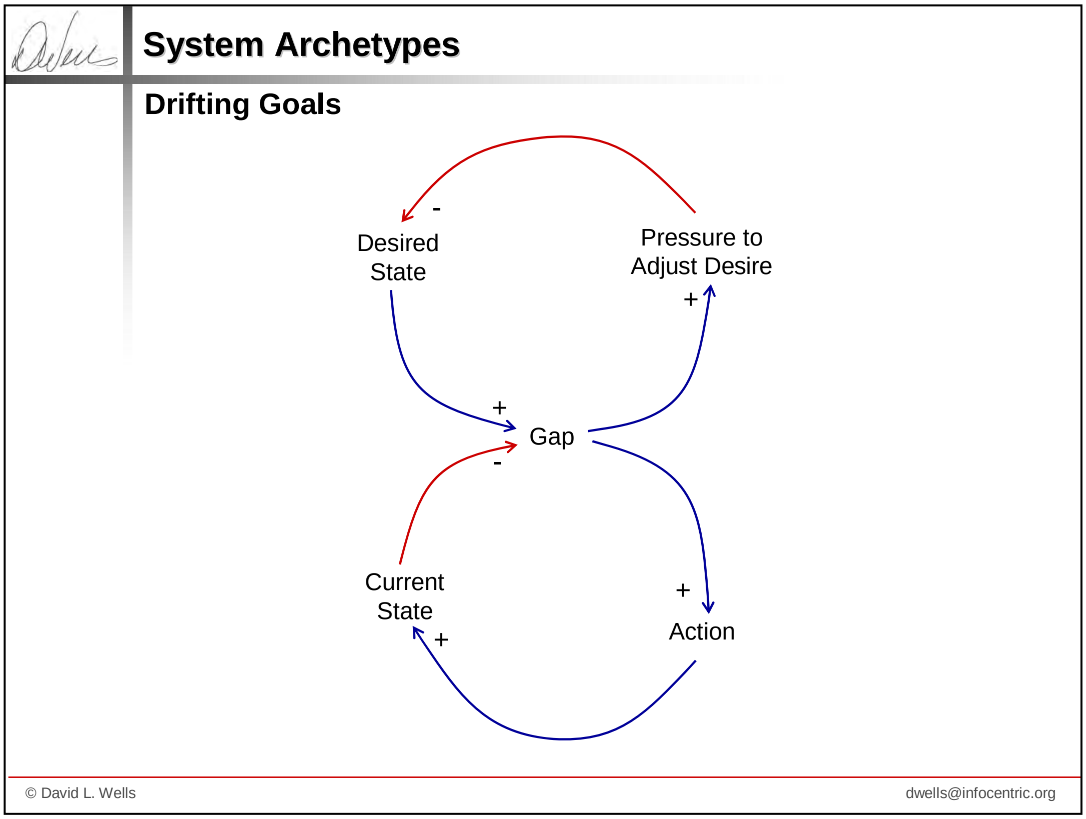
- **In the Example** the balancing loop roles are
  - ✓ Workforce Capacity describes the current state.
  - ✓ Workload establishes the desired state.
  - ✓ Capacity Gap is the difference between current and desired states.
  - ✓ Hiring seeks to balance workforce capacity with workload.



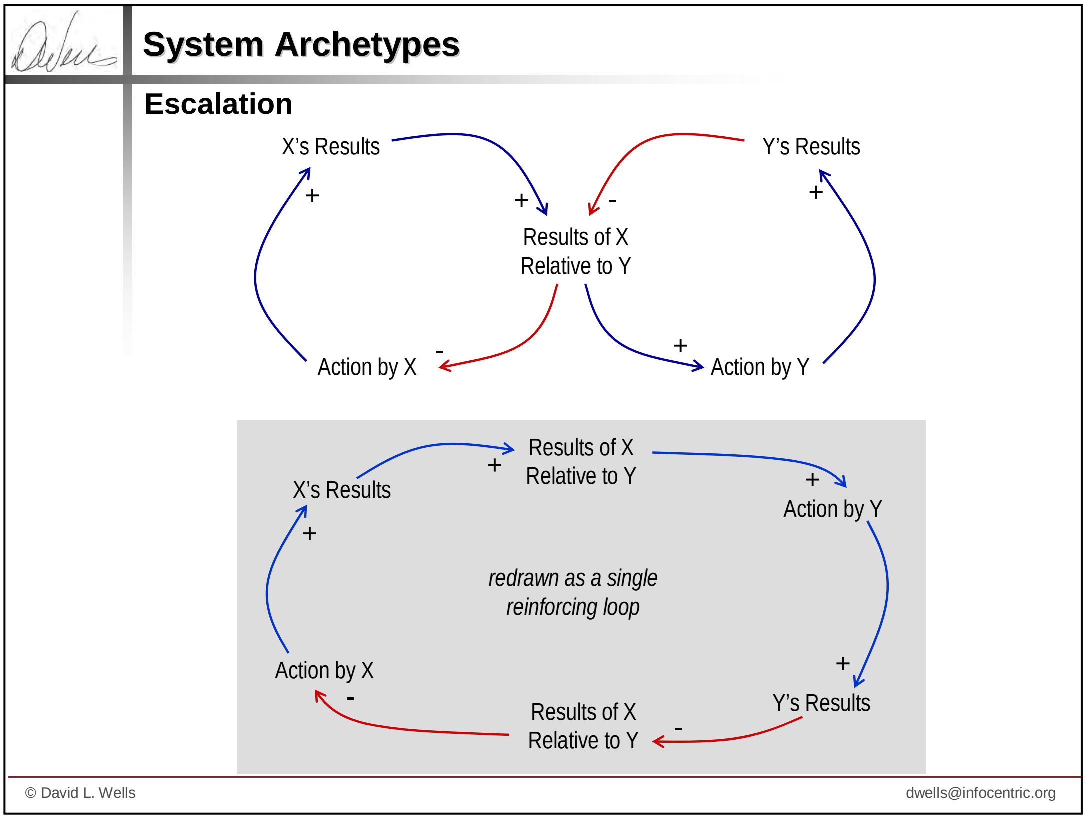
- **Generic Structures in Systems** that can be generalized across many different settings because the underlying relationships are fundamentally the same are known as archetypes. In addition to reinforcing loops and balancing loops, nine system archetypes are widely recognized.



- **Localization with System-Wide Sub-Optimization** is characteristic of Accidental Adversaries.
- **The Characteristics** of this archetype are
  - ✓ Two distinct local reinforcing loops exist, represented by localities X and Y.
  - ✓ X behaves locally to contribute to X's own success.
  - ✓ Y behaves locally to contribute to Y's own success.
  - ✓ X behaves cooperatively to contribute to Y's success.
  - ✓ Y behaves cooperatively to contribute to X's success.
  - ✓ The two cooperative links create a system global reinforcing loop.
  - ✓ X's local actions have unintended consequences that inhibit Y's success.
  - ✓ Y's local actions have unintended consequences that inhibit X's success.
  - ✓ Overall system potential is limited by unintended consequences of local optimization without global system awareness. The value of the global reinforcing loop is diminished.
- **Socio-Cultural Example:** National security vs. workforce economics as they are related to US immigration policies.
- **Consider an Example** where you and I are managing separate but related software development projects. Cooperatively we have agreed to develop shared and reusable software components where practical. Yet each of us, when faced with schedule pressures or conflicting needs, chooses to build local custom components. What are the overall effects for the global system? How might they be resolved?



- **Lower the Bar** describes the common effect of the Drifting Goals archetype.
- **The Characteristics** of this archetype are
  - ✓ Two separate balancing loops exist.
  - ✓ The two loops intersect at a common gap.
  - ✓ One loop contributes the desired state, and another the current state.
  - ✓ The gap simultaneously influences action and causes pressure to adjust the desire – in essence to change the goal.
  - ✓ As the desired state is distorted, the influence on action mutates.
  - ✓ Ultimately the balance that is achieved has little relationship to the initial desired state.
- **Socio-Cultural Example:** Space exploration and the story of NASA.
- **Consider this Example.** I once worked for a company where sales revenue budgets were negotiated annually. In one year actual revenue would significantly exceed the budget, creating pressure to increase budget in the following year. The higher budget in the second year caused actual revenue to fall short of budget, creating pressure to reduce the revenue budget in year three. What are the implications of this see-saw budgeting pattern continuing over several years? What solution can be implemented to stabilize the drifting goals?



- **Competing for Dominance** best describes the nature of the Escalation archetype.

- **The Characteristics** of this archetype are

  ✓ Two separate balancing loops exist, identified here as X and Y.

  ✓ The two loops intersect at a common gap which is defined as relative results.

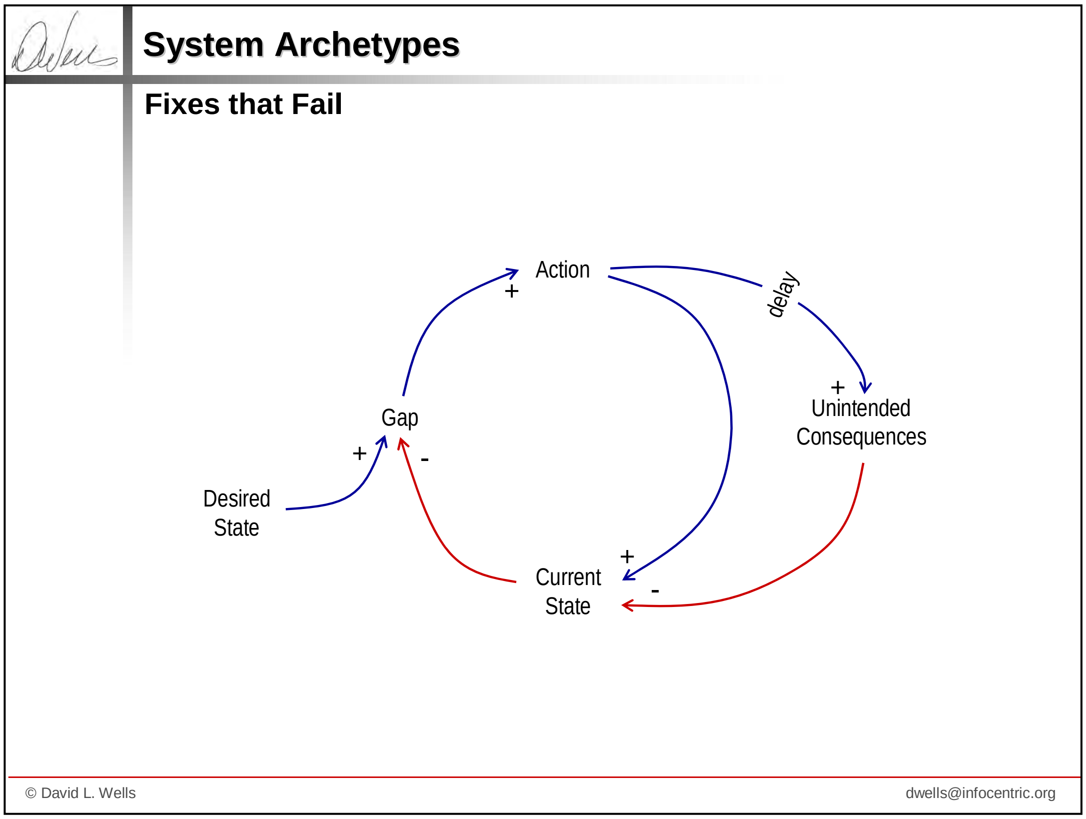
  ✓ The results of action in each loop influence the desired state of the other.

  ✓ The results of action in each loop influence the drive for action in the other.

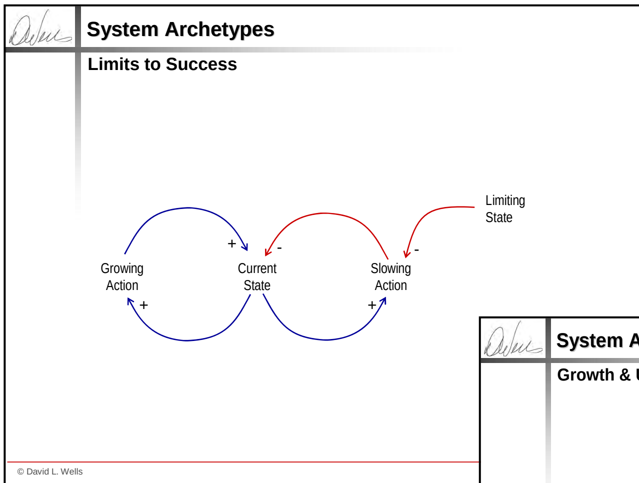
  ✓ The cycle repeats with no apparent end.

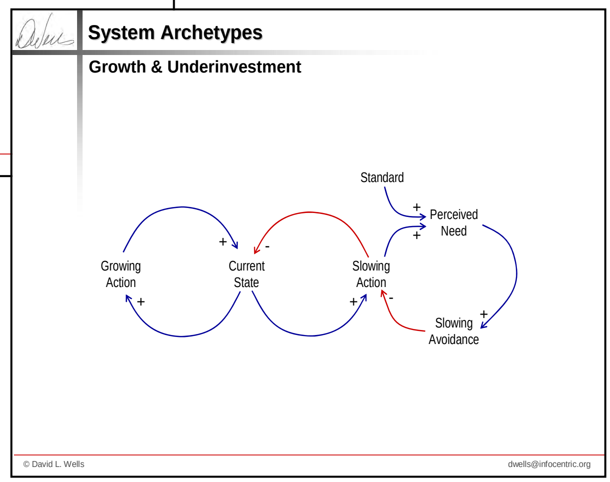
- **Socio-Cultural Example:** The Cold War.

- **Consider the Example** of competitive pricing. It is common for retailers to advertise that they will match any competitor's price. What would be the eventual outcome if two retailers each established a policy of beating the other's best price by five percent? What solution can be applied to avoid that outcome?

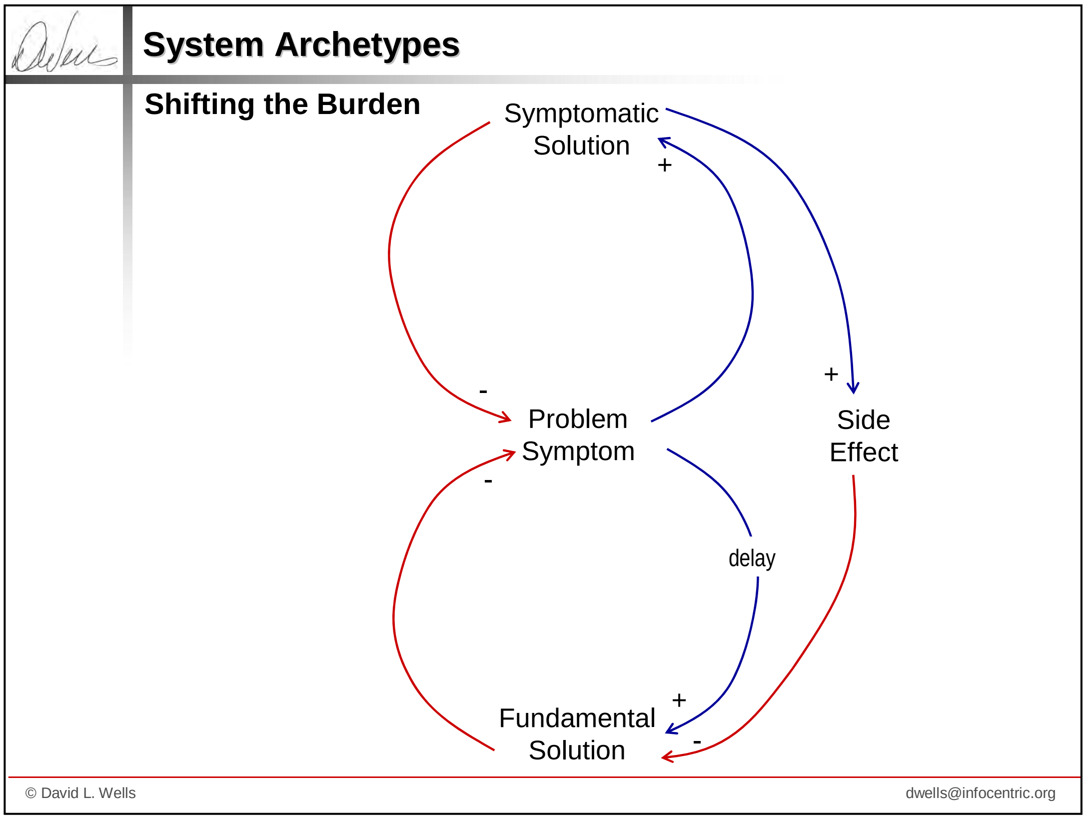


- **The High Cost of the Quick Fix** describes the consequences of Fixes That Fail.
- **The Characteristics** of this archetype are
  - ✓ A balancing loop is applied to produce immediate positive results.
  - ✓ The action of the balancing loop produces side-effects in the form of undesirable and unintended consequences.
  - ✓ A time delay exists between taking action and realizing the side-effects.
  - ✓ The side-effects impede the current state from migrating toward the desired state.
- **Socio-Cultural Example:** Free phone promotions by the wireless telecommunications industry.
- **Consider the Example** of a company that is losing customers due to long wait times at the customer service call center. To improve customer retention the company decides to outsource call center operations. The early result is a visible reduction in wait times and a corresponding reduction of customer attrition due to call center waits. After several months, however, the customer retention rate flattens and begins to trend again toward attrition. What may be the cause and what fundamental solution may resolve it?

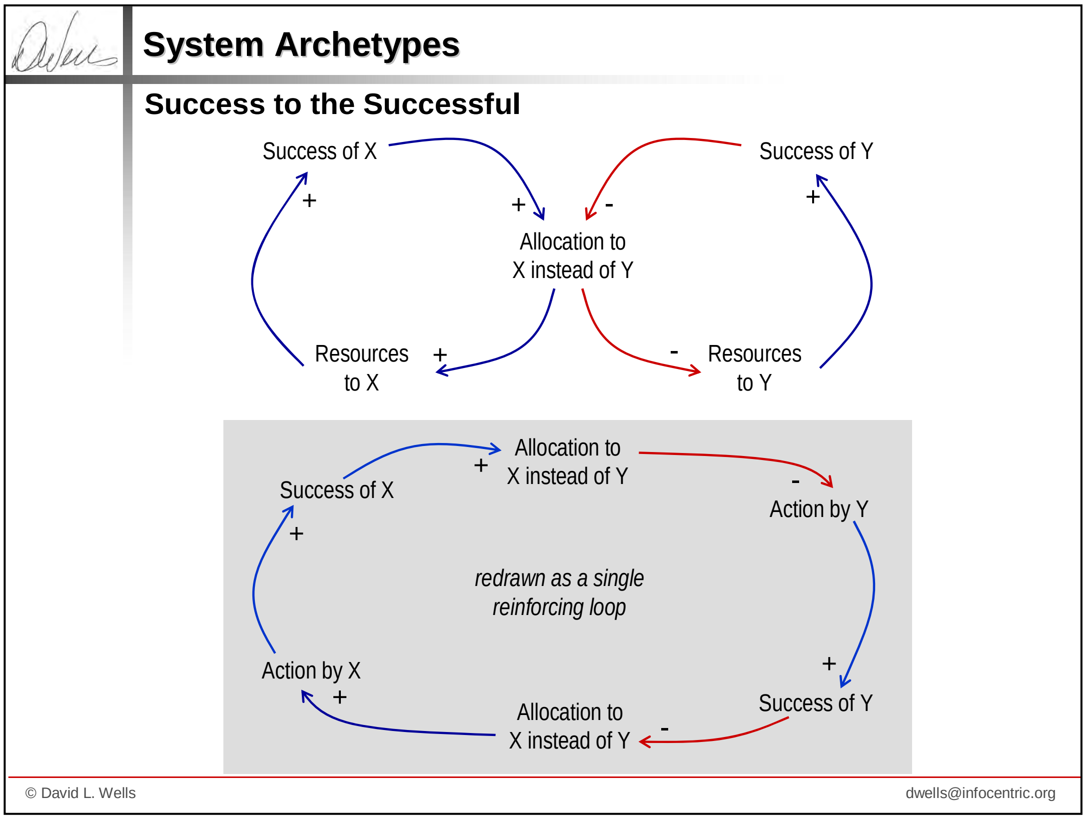




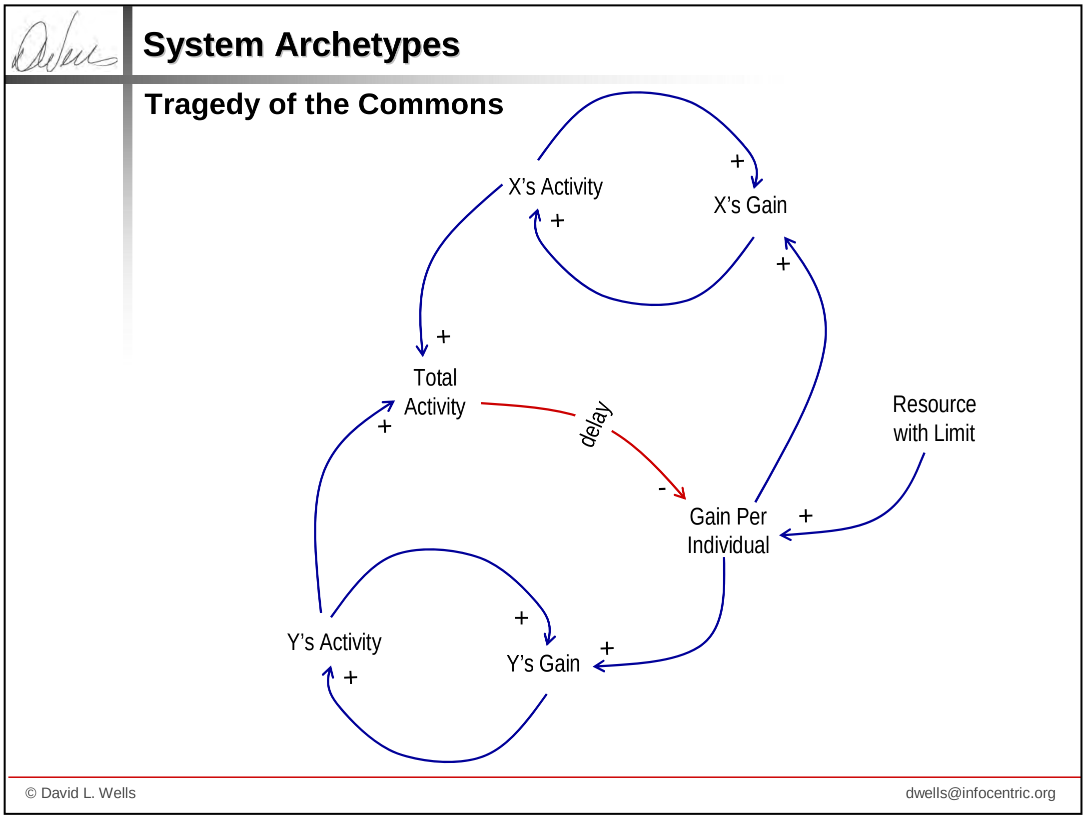
- **Growth Plateau** describes the effects of the Limits to Success archetype.
- **The Characteristics** of this archetype are
  - ✓ A reinforcing loop drives growth of a current state.
  - ✓ As the current state increases it interacts with some limiting state in a way that produces a slowing action.
  - ✓ The slowing action interacts with the current state in a balancing loop that inhibits current state growth and limits the growth effects of the reinforcing loop.
  - ✓ Rapid growth decelerates, flattens, and may ultimately decline.
- **Socio-Cultural Example:** One-hour photo developing services.
- **Many Examples** are common here – capacity constraints, market saturation, aging product lines, emerging technologies, resource limits, etc. How can limiting states be anticipated? How can we adapt for them?
- A common variation of Limits to Success is called Growth and Underinvestment. In this archetype the limiting state is created by failure to invest, often due to short-term pressures such as limited capital. As growth stalls due to lack of resources, incentive to add capacity declines which causes growth to slow even more.



- **The Enduring Band-Aid** describes the effects of Shifting the Burden.
- **The Characteristics** of this archetype are
  - ✓ A short-term solution is implemented that successfully resolves an ongoing problem. The short-term solution is implemented as a balancing loop within the system.
  - ✓ As the short-term solution is used repeatedly it diminishes the drive to implement a more fundamental solution.
  - ✓ Over time, the ability to implement a fundamental solution decreases and reliance on the short-term, symptomatic solution increases.
  - ✓ Ultimately, the short-term solution may produce other side-effects that emerge as new problems.
- **Socio-Cultural Example:** Drug and alcohol dependency.
- **A Common Example** here is overuse of temporary labor to balance workforce capacity with workload demands. Temporary labor satisfies the immediate need to increase capacity. But, when used repeatedly, the percentage of the workforce that is classified as temporary grows and many “temporary” workers become a permanent part of the workforce. Ultimately issues of Fair Labor Standards Act (FLSA) compliance, benefits eligibility, and such emerge – sometimes resulting in legal action and financial penalties. How might temporary labor be used without the burden-shifting side effects?



- **Winners and. Losers** describes the effects of Success to the Successful, which makes win-win systems difficult to achieve.
- **The Characteristics** of this archetype are
  - ✓ Two activities in a system compete for the same limited set of resources.
  - ✓ Both are represented by reinforcing loops where resources drive success, which in turn drives resources.
  - ✓ The early success of X creates incentive to allocate more resources to X.
  - ✓ Allocation of resources to X instead of Y increases X's ability to succeed.
  - ✓ Allocation of resources to X instead of Y decreases Y's ability for success.
  - ✓ Continuation of the cycle reinforces positive results of X.
  - ✓ Continuation of the cycle reinforces negative results of Y.
  - ✓ Ultimately X is sustained while Y fails.
- **Socio-Cultural Example:** Windows vs. Macintosh in the 1990's.
- **Consider the Example** of two departments that are competing for priority of IT projects. Marketing needs a 360 degree view of customers. Research department needs modeling and simulation to drive innovation of new products. Both projects are initiated at similar times. In only a few months marketing illustrates success with campaign effectiveness metrics. In the same short time span, research has only anecdotal justification for the simulation project. The demonstrable success of marketing results in more resources for that project, making fewer resources available to research.



- **Shared Resource Overload** is the nature of Tragedy of the Commons.
- **The Characteristics** of this archetype are
  - ✓ Two activities in a system depend on a shared resource of limited capacity.
  - ✓ Both grow through activity that produces individual gain – illustrated as two reinforcing loops.
  - ✓ With growth over time, the total activity first approaches and then exceeds the limited capacity of the resource.
  - ✓ Growth opportunities for both activities disappear when the capacity of the resource exceeded.
  - ✓ Ultimately the resource is depleted which stalls growth of both X and Y.
- **Socio-Cultural Example:** Fossil-fuel based energy supplies.
- **Consider the Example** of a company that depends extensively on the subject and domain knowledge of one person. Initially that person provides valuable knowledge that fuels growth of programs, products, marketing, sales, and quality. As each area grows the demands on the expert increase to the point where he can't keep pace with demand even by working around the clock. Ultimately the demands become burdensome, the job becomes unrewarding, and the expert resigns. What are the impacts to the company? To the individual? Could the situation have been avoided? What system changes are needed?

Part Three

Systems Thinking Models

Causal Loop Diagrams

Stock and Flow Diagrams

Behavior over Time Graphs

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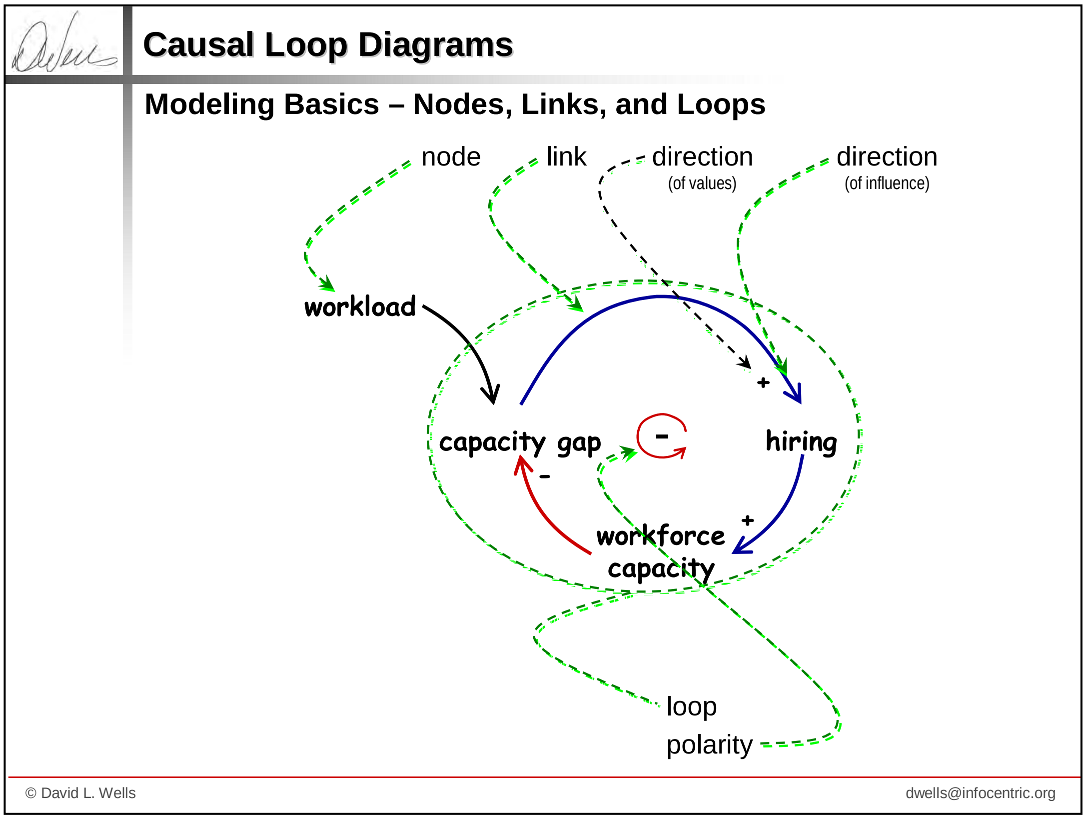
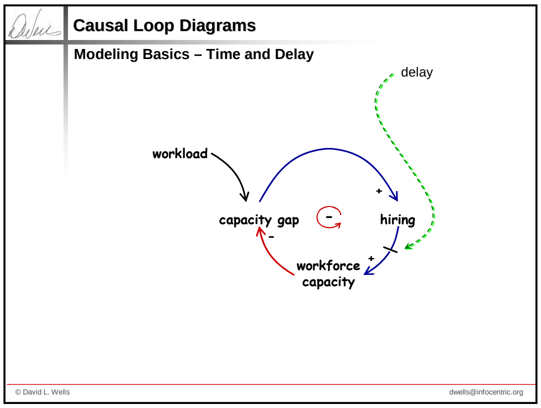
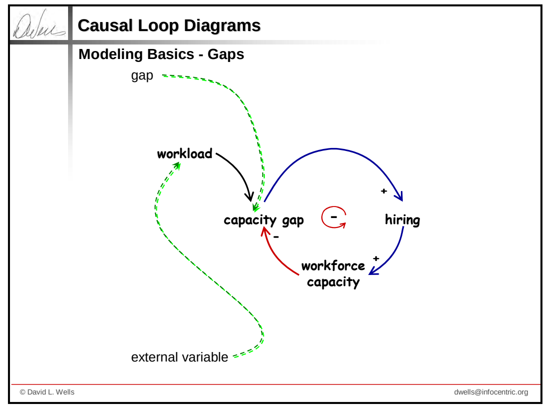
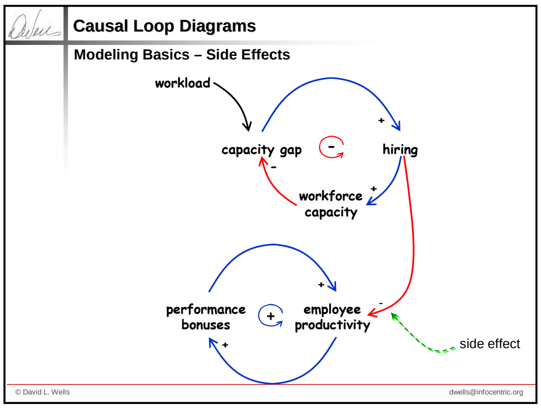


- **Visually Representing System Behavior** is widely practiced in systems thinking with a Causal Loop Diagram (CLD). Causal loop diagramming is a form of Cause and Effect modeling. The diagrams represent a systems and behaviors as a collection of
  - ✓ Nodes that illustrate the things in the system,
  - ✓ Links that illustrate interactions and influences,
  - ✓ Direction of Values – a property of a link indicating whether influence causes values to move up and down in the same direction or in opposite directions,
  - ✓ Direction of Influence – a property of a link drawn as an arrowhead to show which node causes influence and which node demonstrates effects of influence,
  - ✓ Loops that are formed by a set of nodes and links in a way that creates a circular feedback process,
  - ✓ Loop Polarity – a property of a loop which determines whether it is a reinforcing (positive polarity) loop or a balancing (negative polarity) loop.







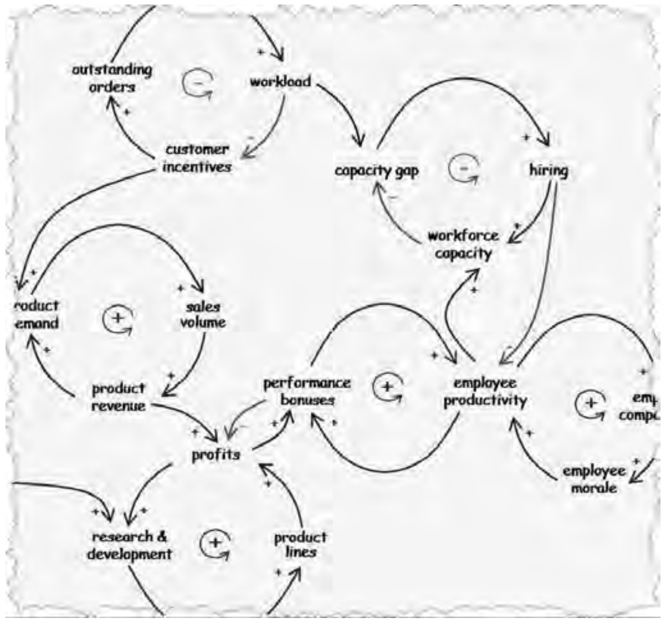
- **The Timing of Influence** by one node upon another is not always immediate. A delay may occur between cause at an influencing node and effect at the influenced node. Delay is an important concept in understanding system behaviors. Consider the role of delay in archetypes such as Fixes that Fail and Shifting the Burden. In the Example, an increase in hiring does not immediately bring increased workforce capacity.

- **The Difference between Current and Desired States** is called a Gap, and is an important concept when modeling balancing loops. An External Variable – a node that is outside of the loop – influences the gap. Failure to look at the external variables creates a false view of cause and effect – a difference between the perceived state and the actual state. In the Example the capacity gap is influenced by workload, a variable that is external to the balancing loop.

- **Unintended Consequences** are often the result of Side Effects – the frequently unrecognized influences of an action on another part of a system. Side effects are typically the result of narrow and localized views of a system. In the Example the act of hiring to balance workload with workforce capacity has a side effect. It impedes growth of employee productivity.

Causal Loop Diagrams

Modeling Systems – Scope of the Model



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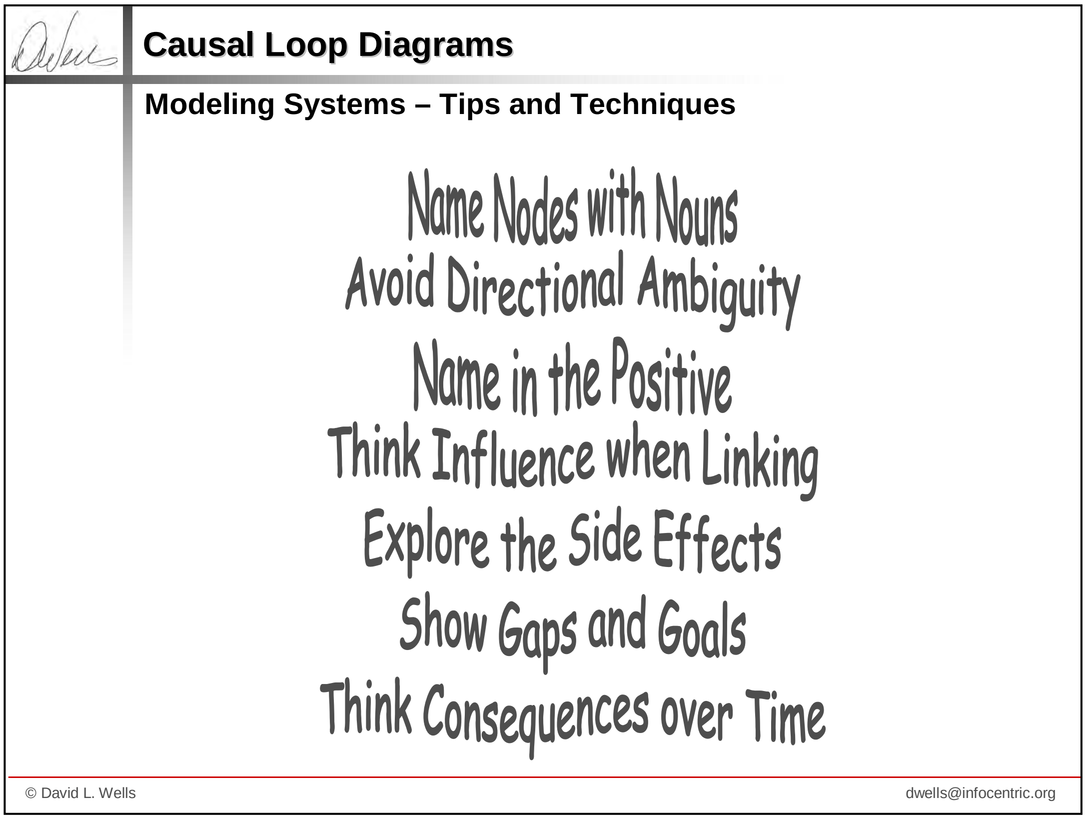
- **Purpose of the Model:** Knowing why you are modeling a system is as important as knowing what you are modeling. When modeling to design analytics, begin with the areas of focus for the analytics. When modeling to understand cause-and-effect consider using the archetypes as a start.

- **Content of the Model:** A system model is a set of related loops with intersections at the nodes and intra-loop links such as side effects. Every sustainable system must include both reinforcing loops and balancing loops. A system of only reinforcing loops continues to expand eventual self-destruction. A system of only balancing loops stabilizes to the point of atrophy.

- **System Complexity in the Model:** The intersection nodes – those that participate in two or more loops – are the core of system complexity. Intersection nodes are prone to side effects. The nodes receive multiple influences which makes them especially difficult to understand, to forecast, and to affect through systemic changes.

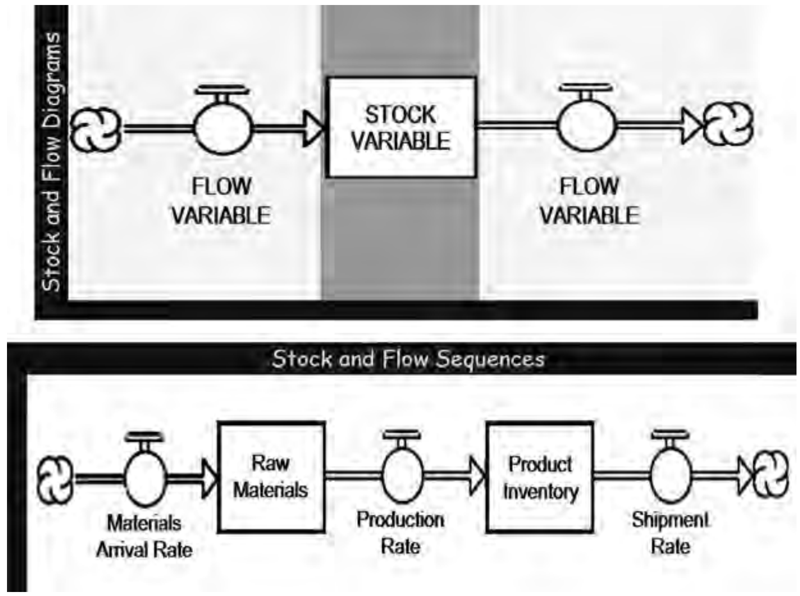
- **Boundaries of the Model:** Every system is a part of some larger system. Therefore it is possible to continue modeling infinitely. Stop modeling when you have acquired the knowledge and information that satisfies the purpose of the model. Stopping too quickly, however, brings the risk that you'll overlook side effects and unintended consequences.



- **Name Nodes with Nouns:** The nodes represent things in a system and should be named using nouns. Avoid verbs, but don't hesitate to use enough qualifying words to make the meaning clear.
- **Avoid Directional Ambiguity:** Verify that both nodes participating in a link are named in such a way that the meaning of "up" and "down" movement is clear.
- **Name in the Positive:** Use names for which the positive sense is preferable – for example "profit" instead of "loss."
- **Think Influence when Linking:** Remember that links represent the influence of one node upon another. They are not just time sequences.
- **Explore the Side Effects:** Actively think about possible side effects of every influence that is shown in the model. Ask "*what else might be influenced?"* Then determine if the effect is significant in the scope of the model.
- **Show Gaps and Goals:** Every balancing loop has a goal that is represented as the desired state. Explicitly show the two states, the gap, and the external influences on the desired state.
- **Think Consequences over Time:** Consider both short term and long term effects of each influence in the model. Think about any differences between perceived and actual states. Include delays in the model where they are needed.

Stock and Flow Diagrams

Technique and Purpose



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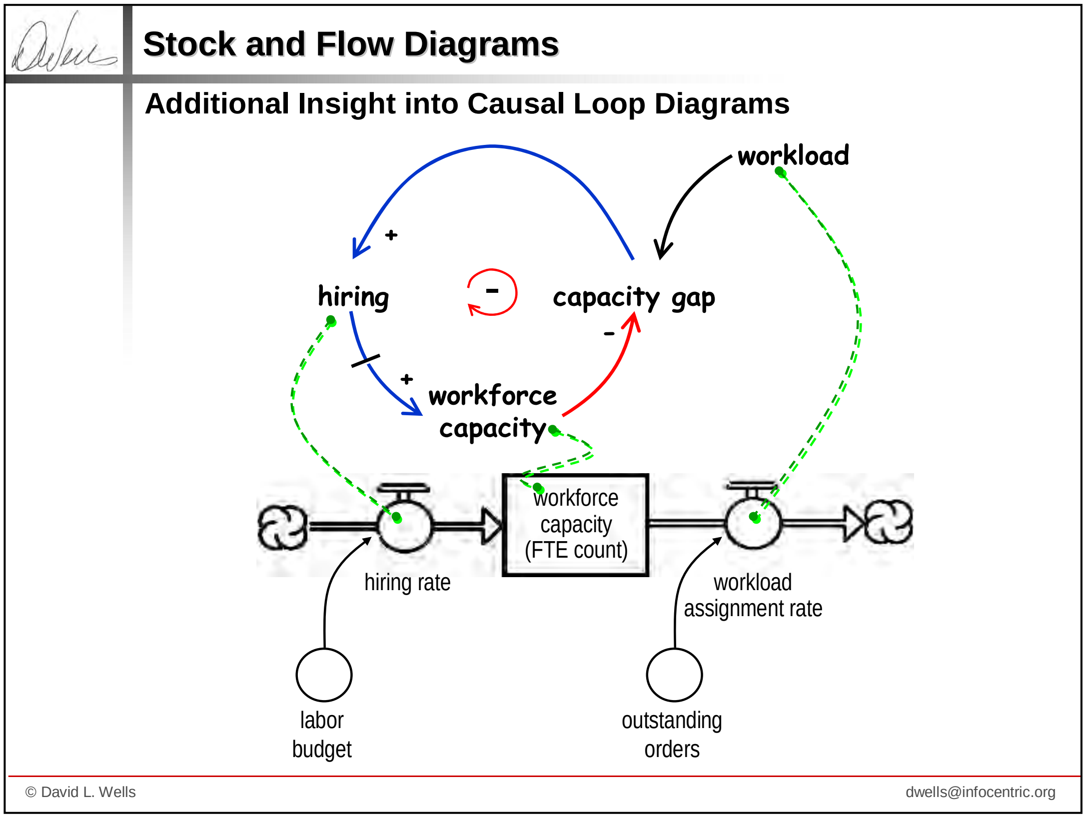
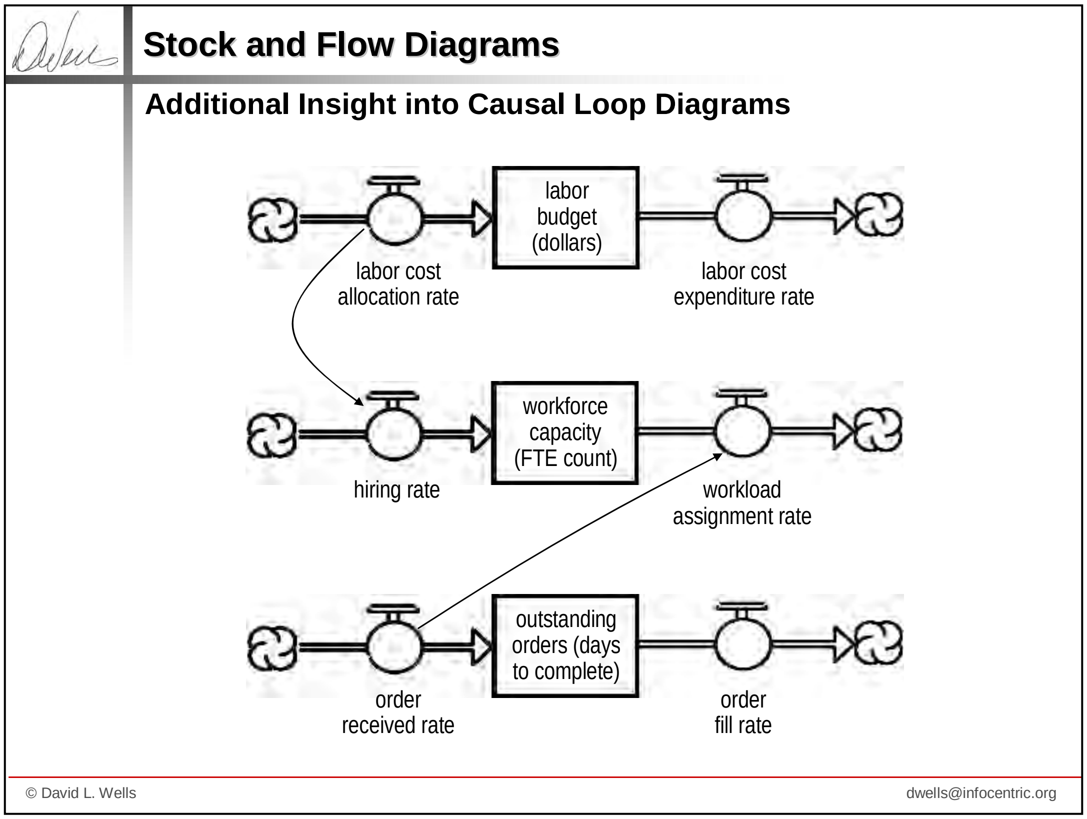
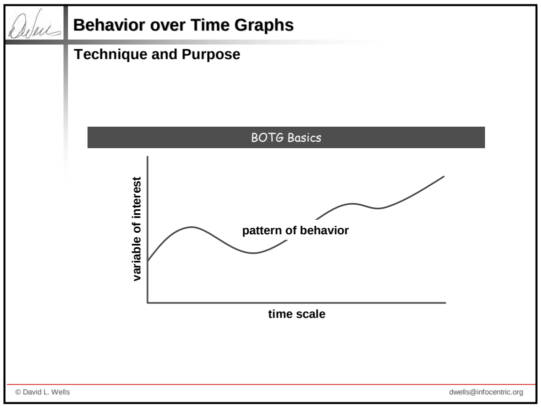
- **Understanding the Dynamics** of things that accumulate in a system is often important when modeling and simulating system behaviors. Stock and Flow Diagrams are a modeling technique that is designed to meet this need.
- **Things that Accumulate** in a system are called Stock. Stock changes occur through the influences of Flows. The relationships of stocks and flows are graphically represented using stock and flow diagrams.
- **A Stock** is an accumulation of something in a system – either concrete and tangible things (i.e., dollars) or abstract and intangible things (i.e., knowledge). Tangible stocks are accumulations of consumable resources. Intangible stocks are accumulations of catalytic resources. Stock and flow diagrams are commonly used to model the dynamics of consumable resources.
- **A Flow** is an action that influences a stock either by increasing or by decreasing the stock. Flows are of two kinds – In-Flows that increase stocks and Out-Flows that decrease stocks.
- **External Influences** may influence the rate of a flow. Converters identify the things that influence flow rate. Connectors link converters to flows.
- **Measurement** is a key concept of stock and flow diagramming. Stocks are measured as units. Flows are measured as units per time period (e.g., rate of flow).

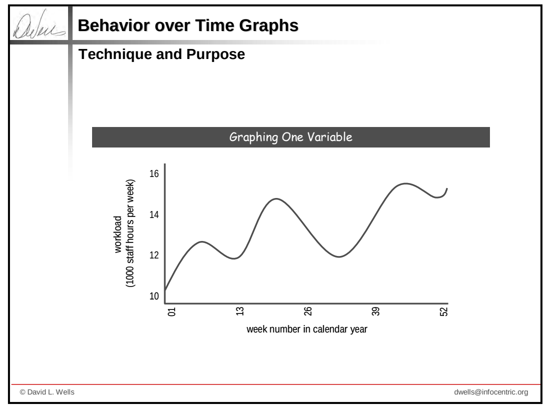


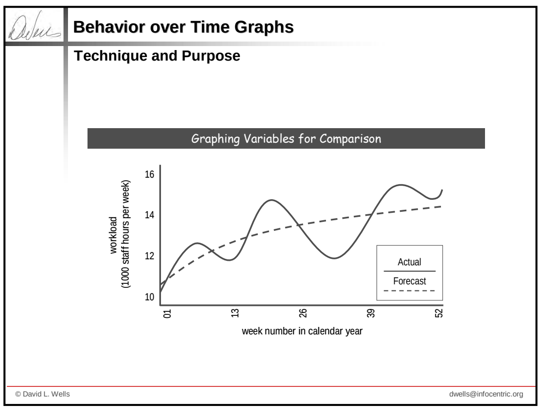
- **From CLD to Stock and Flow:** A systematic process of working from a CLD to create stock and flow diagrams uses a sequence of:
  - ✓ Identify critical behaviors of the system – those that are problematic, under study of analysis, or central to the goals and strategies of the organization.
  - ✓ Identify the stocks that participate in critical behaviors– those things that are accumulated in the system upon which critical behaviors depend.
  - ✓ Name each stock with a term that is quantitative but not comparative. (The example adds "(FTE count)" to the name "workforce capacity" to make it quantitative. But it does not say "more workforce capacity" which is comparative language.)
  - ✓ Examine every link to each stock to determine if it becomes a flow. If the influence is one that changes the accumulated quantity of the stock, then it is a flow.
  - ✓ Add each flow to the diagram expressing the influence as units-over-time or rate of flow. (The example translates "hiring" from the CLD to "hiring rate" in the stock and flow diagram, and "workload" to "workload assignment rate.")
  - ✓ Examine each flow in context of the system-wide CLD to identify links that are converters – influences that regulate or otherwise affect the rate of flow. Labor budget and outstanding orders are converters in the example.
  - ✓ Mark the boundaries – start and end – of the model.



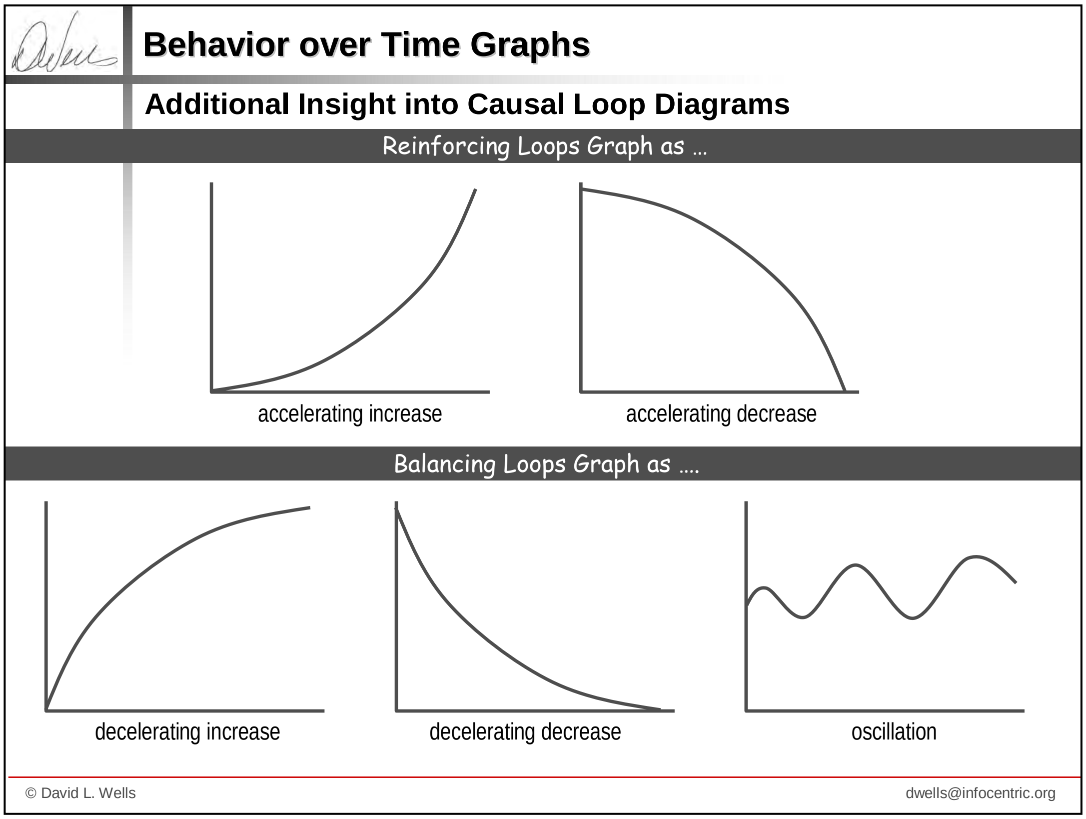
- **Multiple Stocks and Flows:** It is possible – even probable – to produce many stock-and-flow sequences from a single CLD. (This effect is similar to the probability of many state transition models from one data model.) When this occurs, valuable insight can be derived by identifying the overlaps where a flow in one sequence acts as a converter in another sequence. Consider this example. “Labor budget” is a stock whose in-flow is “labor cost allocation rate.” The cost allocation rate is the true converter affecting hiring rate. Similarly, “outstanding orders” is a stock with the in-flow of “order received rate.” In both instances the converter link is a flow-to-flow connection. The stock itself is never used as a converter. The result of this analysis is greater insight that may add understanding and detail to the CLD.







- **A Simple Tool:** A Behavior over Time Graph (BOTG) is a simple and widely used tool to understand patterns of behavior over a period of time. It removes attention from isolated events which leads to deeper understanding of systemic behaviors.
- **A Familiar Tool:** Virtually everyone is familiar with BOTG and understands how to read them. But knowing how to read a graph does not imply knowing how to create one. A few simple guidelines:
  - ✓ Always represent time on the X (horizontal) axis.
  - ✓ Label the X axis in units of time with defined beginning and ending points.
  - ✓ Use a time scale that has meaning to the purpose of analysis, and that is divided into equal units or spans of time.
  - ✓ Always represent the variable of study on the Y (vertical) axis.
  - ✓ Label the Y axis with the name of the variable of study.
  - ✓ Use a quantitative scale for the variable that has meaning to the purpose of analysis.
  - ✓ Set minimum and maximum values of the Y axis scale to describe the realities of the variable of study.
  - ✓ Plot multiple variables on the same graph only when it is useful to examine the correlation between them.
  - ✓ When plotting multiple variables label the Y axis with the subject of study, and include a legend that clearly identifies each variable on the graph.



- **From CLD to BOTG:** The things in a CLD that are graphed using BOTG are typically the nodes of loops – either reinforcing or balancing loops. The slide above illustrates the basic behavioral patterns that you can expect of variables based on their roles and relationships as nodes in a CLD. Reinforcing loops graph as two distinct patterns: (1) growth at an accelerating rate over time, and (2) decline at an accelerating rate over time. Balancing loops graph as three distinct patterns: (1) rapid growth early that slows over time, (2) 4apid decline early that slows over time, (3) an oscillating up-and-down pattern over time.

- **From BOTG to CLD:** You may frequently begin with a BOTG, which illustrates a behavior pattern and tells you *what* is happening. Your challenge, perhaps, is to find out *why* it is happening. The patterns described above are useful as a guide to getting started with the analysis of "why" – the cause-and-effect analysis. If the variable in question is already represented in a CLD, then you'll want to seek the loops in that CLD where the variable participates as a node in the same kind of loop as is indicated by the behavioral pattern. If there is no existing CLD, then begin to construct one by modeling the behavior that is represented by the BOTG – either a reinforcing loop or a balancing loop focusing on the variable in question. The CLD modeling activity will lead you to discover the influences responsible for the behavioral pattern.

Part Four

Systems Thinking and Business Analytics

Purposeful Analytics

Insightful Analytics

Actionable Analytics

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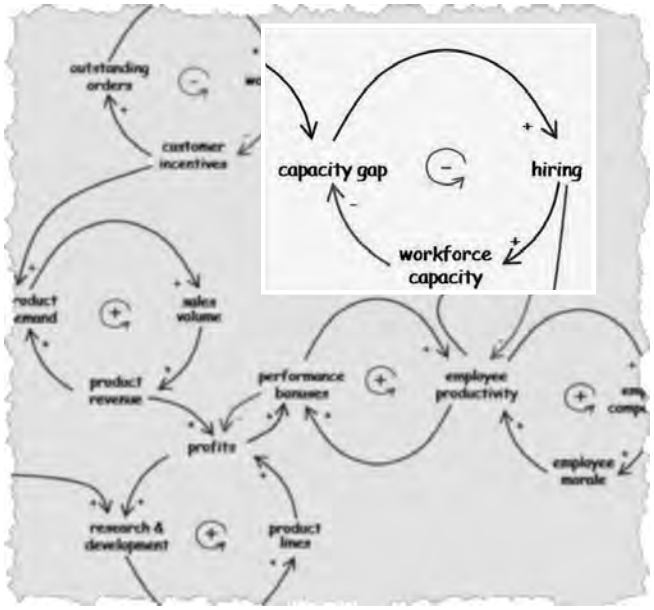
Purposeful Analytics

Goal Seeking and Correction



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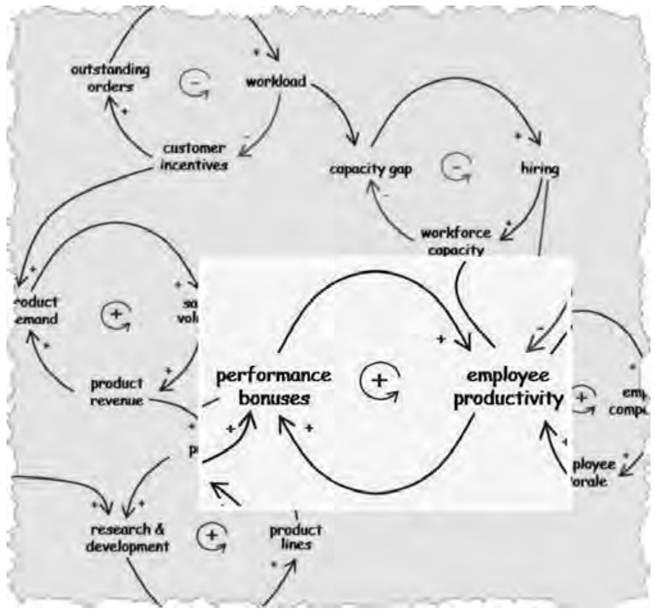
- **Balancing Loops** describe the system dynamics that need to be understood when your objective is one of goal seeking or correction. Balancing loops are, in fact, also known as goal-seeking loops.

- **When Modeling System Behaviors**, begin with the business scope and context for the analytics. Within that scope, identify the variables of interest – those at which goals or correction are targeted – as the initial nodes of one or more balancing loops. As you study the system dynamics, the CLD will naturally extend to include reinforcing loops. The balancing loops are the starting place because they align with the stated objectives, but no system model is complete unless it has both balancing and reinforcing loops.

- **When Using Analytics** for goal-seeking or correction purposes examine the CLD to find the balancing loops in which variables of interest participate as nodes. Assume, for example, that you are a business analyst viewing a graph that illustrates a disturbing pattern of behavior over time. The variables represented in the graph behave as they do because of the influences that affect them. These influences are found by examining the balancing loops in which they participate – the place where you'll find cause and effect. If you already have CLD's, then the job is half done. If not, then take the opportunity to start building a system model.

Purposeful Analytics

Growth



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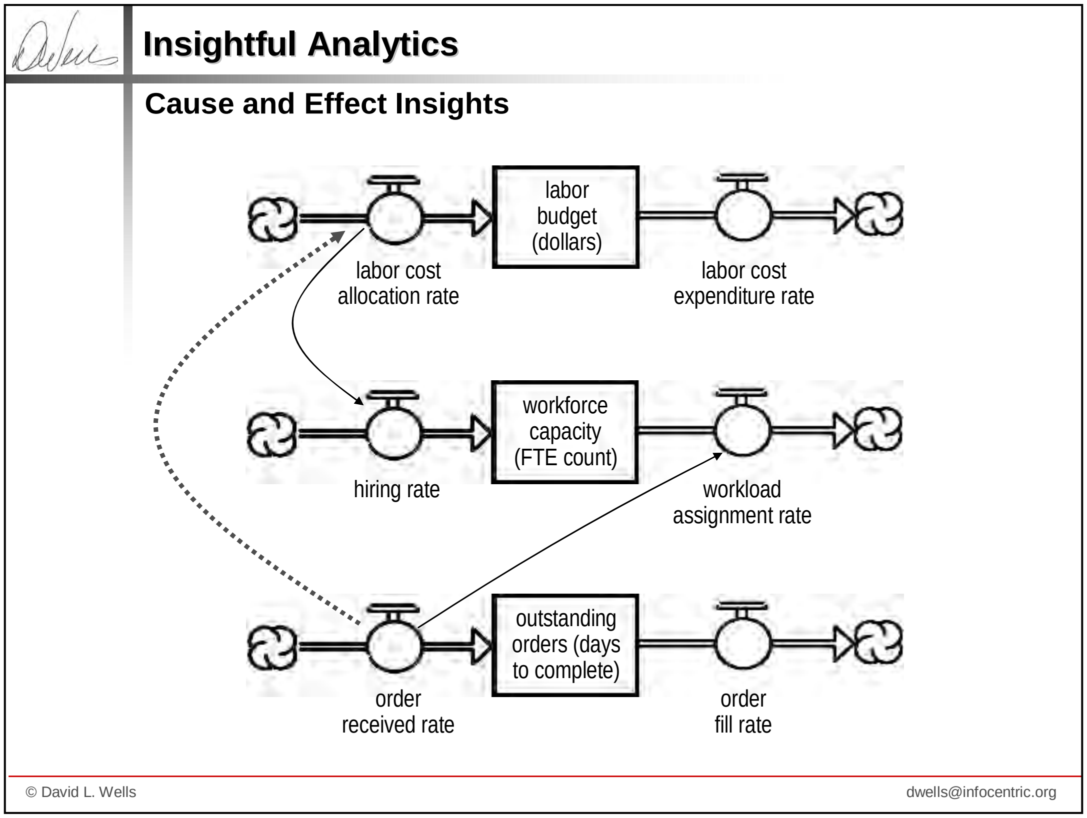
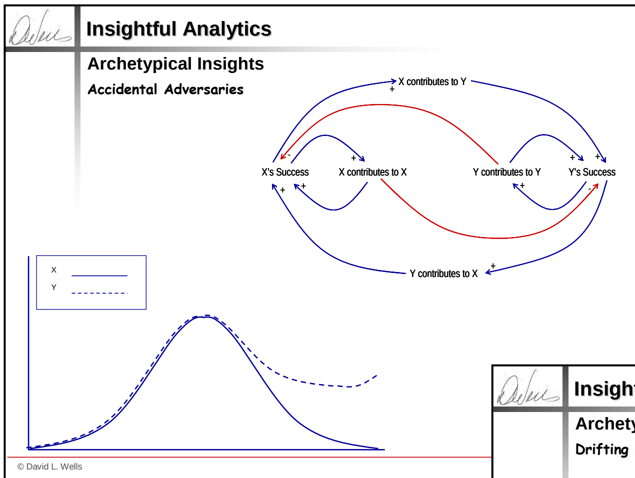
- **Reinforcing Loops** describe the system dynamics that need to be understood when your objective is one of growth.

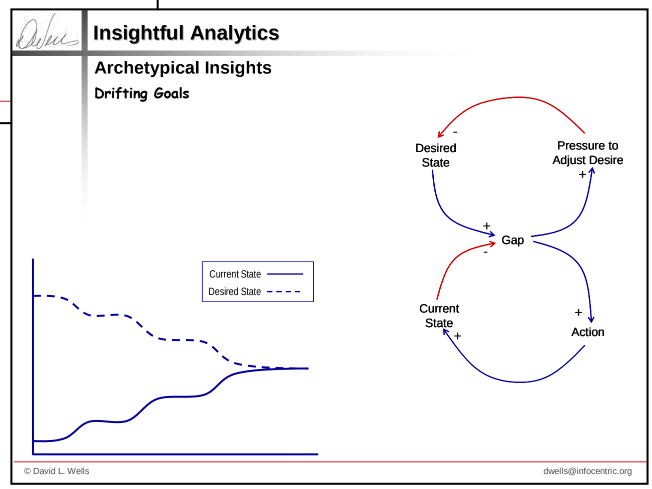
- **When Modeling System Behaviors**, begin with the business scope and context for the analytics. Within that scope, identify the variables of interest – those at which growth targeted – as the initial nodes of one or more reinforcing loops. As you study the system dynamics, the CLD will naturally extend to include balancing loops. Reinforcing loops are the starting place because they align with the stated objectives, but no system model is complete unless it has both reinforcing and balancing loops.

- **When Using Analytics** for to understand growth, examine the CLD to find the reinforcing loops in which variables of interest participate as nodes. Assume once again, that you are a business analyst viewing a graph that illustrates a pattern of stalled or declining growth. The variables represented in the graph behave as they do because of the influences that affect them. These influences are found by examining the reinforcing loops in which they participate.



- **The Example** above is a stock and flow map presented earlier, with only one change. The previously presented model did not include the link from "order received rate" to "labor cost allocation rate" that is shown as a dotted line. This example illustrates
  - ✓ the Insight to see that labor cost budgeting is not directly influenced by the rate at which new orders are received,
  - ✓ the Understanding to recognize that this situation isolates labor budgets from the realities of workload dynamics, which is a fundamental cause of the gap between workload and workforce capacity,
  - ✓ the Reasoning basis to conclude that the gap will improve if order received rate becomes an influence to determine labor cost allocations,
  - ✓ the Planning requirement to define a course of action through which labor cost allocations are influenced by orders received,
  - ✓ the Innovation opportunity to establish a new process through which order received rate influences labor cost allocations, which in turn influences hiring rate and narrows the workload-capacity gap.

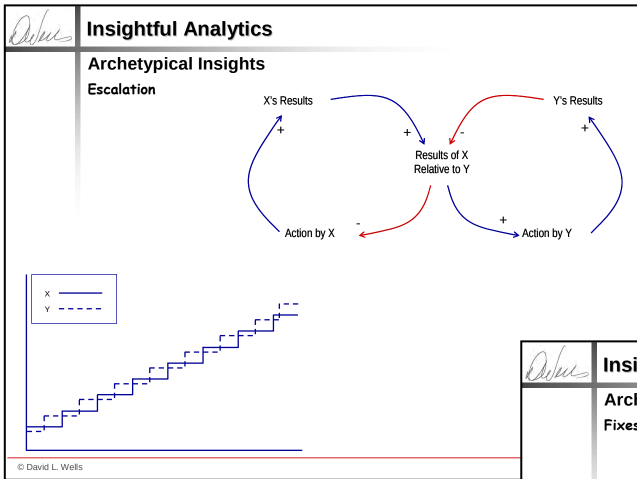


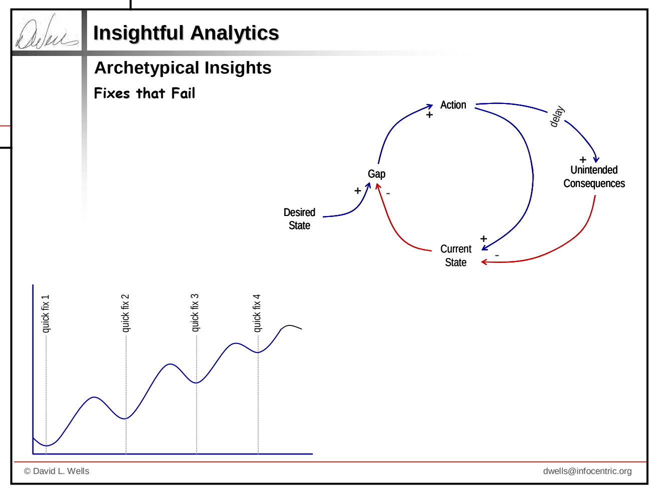


- **The Archetypes** described earlier are an effective way to gain insight from analytics. It is valuable to understand the relationships between archetypes shown as CLD's and shown as BOTG's. Whether you're looking at a BOTG and asking "why?" or at a CLD and asking "what should I expect?" these abstract models provide a way to see inside the dynamics of systems.

- **Accidental Adversaries** graphs as two activities – X and Y – which both experience accelerating growth early in the time scale. As local optimization limits success potential of both activities, they each decline in the later stages of the time scale.

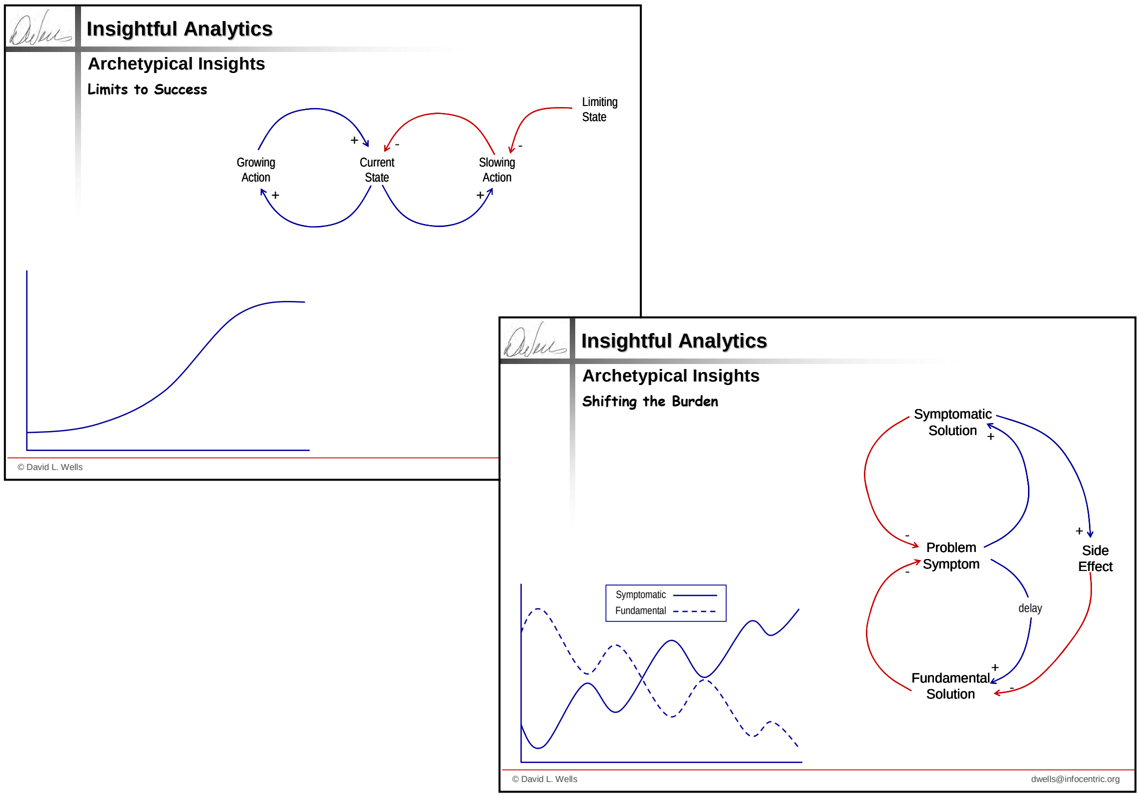
- **Drifting Goals** graphs as mildly oscillating patterns of both the current state and the desired state. Current state increases slightly over time, as desired state experiences a slight decrease. Eventually equilibrium is reached and both states flatten at a level that is less than the original desired state.





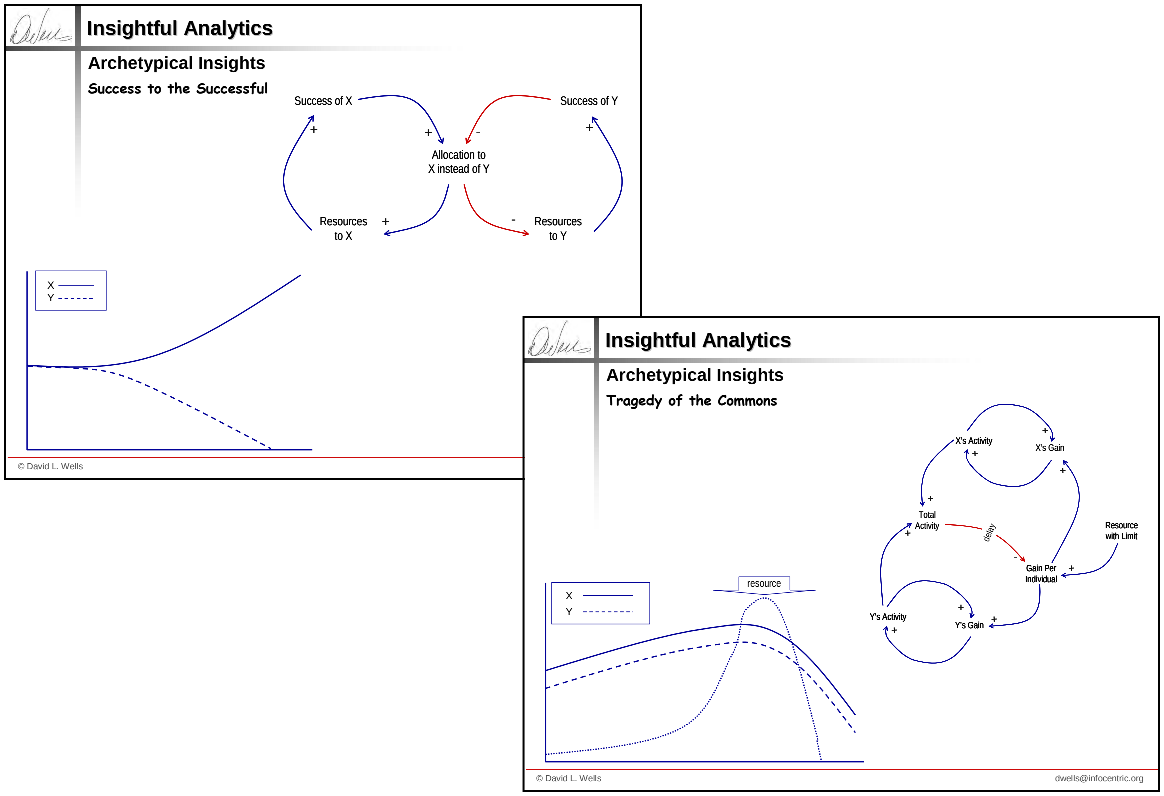
- **Escalation** graphs as two activities – X and Y – that each grow in a "stair step" pattern, with each as the driving force for the next growth step of the other.

- **Fixes that Fail** exhibits an oscillating pattern of increase followed by decrease. Each of the increases coincides with the introduction of a symptomatic solution. Each decrease that follows is the result of unintended consequences of the fix that become visible only after some delay. It is common that the time intervals between cycles decrease over time, and that the amplitude of each wave also shrinks.



- **Limits to Success** graphs as a growth curve that exhibits early acceleration, followed with deceleration and eventual flattening over time. Growth and Underinvestment – a special case of Limits to Success – shows a similar pattern of behavior over time.

- **Shifting the Burden** shows an oscillating pattern of erratic growth of a symptomatic solution. A corresponding (but not always graphed) pattern of oscillating decline in the viability of a fundamental solution occurs simultaneously.



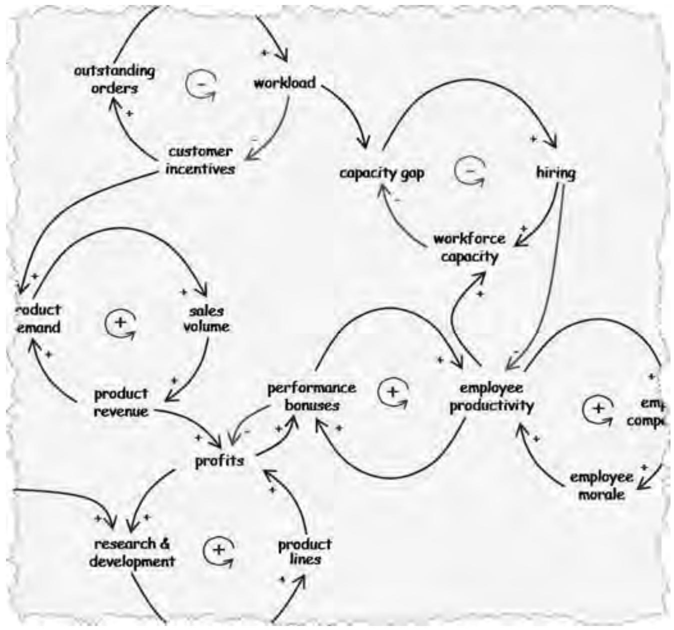
- **Success to the Successful** graphs as two activities – X and Y – with divergent patterns. The activity to first demonstrate success (illustrated here as X) shows a growth curve, while the other shows a corresponding decline. Over time the gap between growth of the successful activity and decline of the failing activity widens.

- **Tragedy of the Commons** illustrates three variables. Two activities – X and Y – exhibit early and steady incline followed by late and rapid decline. The common resource of limited capacity exhibits rapid growth of demand (coincidental with the growth peak of the two activities) followed by very rapid decline.

Insightful Analytics

Insight and Learning

"Learning is the ultimate feedback loop!"



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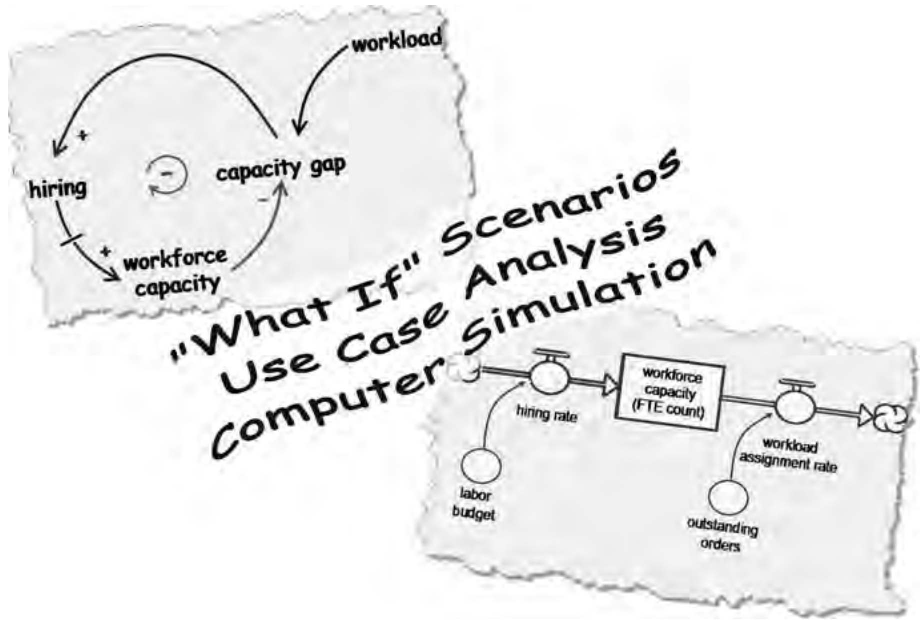
- **The Big Picture** is an important element of systems thinking. Understanding and insight only translate to learning when considered in big-picture context. A system consists of many parts that interact in many ways – as feedback within loops and as feedback between loops. Abstraction is a significant step to seeing the big picture and making learning possible. Abstraction is the act of removing details and specifics from something. Abstraction makes us able to see the general concepts, ideas, or impacts of a thing or a class of similar things.
- **Systems Thinking Abstraction** includes the archetypes which remove the specifics of a particular system to illustrate general behavior patterns in systems. It is also practical to create your own system abstractions. Consider, for example, what you might discover by creating a "higher level" CLD where each loop becomes a node with its details hidden. First, you'll begin to ask new and different questions about influences and interactions among the more abstract nodes. Next you'll ask new questions about what lies outside of the system boundaries. The possibilities of where that may lead are without limit.
- **Learning** is a cognitive process of acquiring skill or knowledge. Learning is the ultimate feedback loop! When you understand an abstraction well enough to apply it in new and different circumstances, then you have learned. When you understand Shifting the Burden enough to prevent it instead of fixing it, then you have made a difference.

Actionable Analytics

Views into the Future



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- **The Right Action** often depends on seeing into the future, not simply looking at the events and patterns of the past, as BOTG's do so well. CLD's and stock and flow maps are the more effective view-of-the-future tools.

- **CLDs** provide the model for "what if" scenarios and more formal and structured use-case analysis

- **Stock and Flow Maps** are the basis for predictive modeling and computer-based simulation. The quantitative nature of these models – stocks measured as units and flows as units per time period – make it practical to define simulation models and apply simulation and predictive analytics tools effectively.

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