WinnCOMM SDR '10 Tutorial

Information Process Architecture

IPA

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IPA Tutorial Outline

1. Introduction
2. Historical Technology Transitions
3. Key Points
4. Information System Framework
5. Information System Structure
6. Context and Communications
7. Applications
8. Future Work

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Introduction to IPA (1)

- **The Software Defined Radio Forum (SDRF) changed its name in 2009 to reflect maturation of SDR technology and broadening of current interests**
- **IPA is a project within Wireless Innovation Forum (WInnF) to explore the architecture of the Information Systems (IS) that are inducing disruptive fundamental changes in our society and the role of communications as fundamental component of such systems**

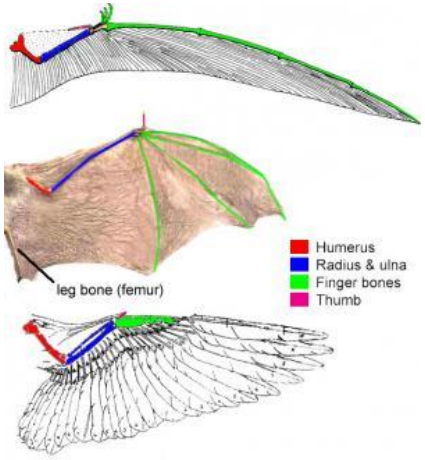
Kindle

Smart Grid

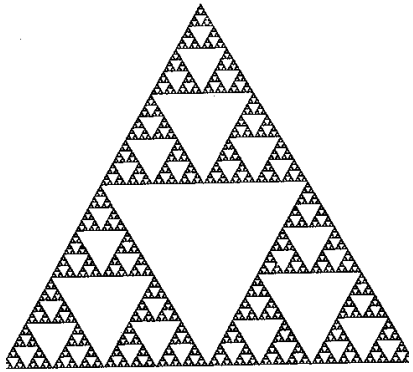
Precision Agriculture

Introduction to IPA (2)

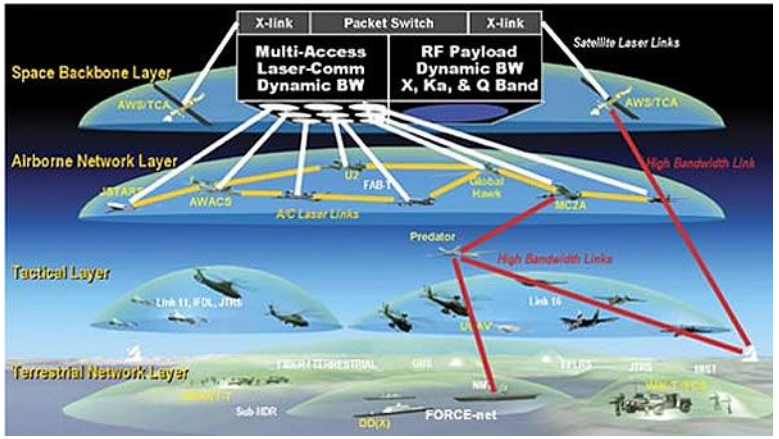
- **Information Systems are implemented as a collection of Processes; even independently developed systems employ processes that are fundamentally similar**
- **The role of communication processes is to make information available in other places and points in time where it is needed**



Homologous

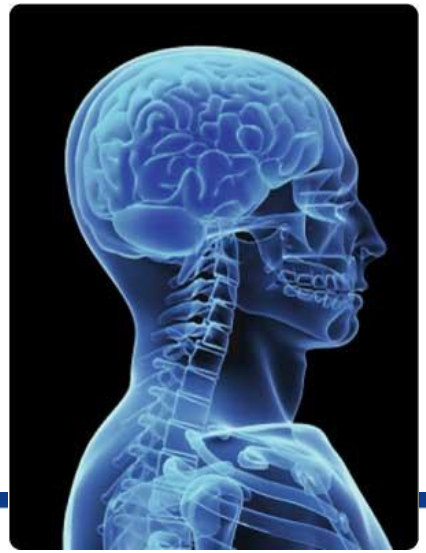


Self-similar



Introduction to IPA (3)

- **IPA is examining the architecture of Information Systems to understand them at a level of abstraction higher than that normally considered by systems engineering**
- **IPA proposes means of describing system architectural elements and their interaction to facilitate interfacing disparate systems**
- **IPA also is examining the nature of Information Systems to determine how cognitive functionality can be introduced by migrating from user controlled processes to autonomous processes**



IPA Status

- **Volume 1:**
  - Concepts and role in society
  - Published in Fall 2010
  - Focus of this talk

	Approved Document WINNF-08-P-0013
Feb 11, 2010	**Commercial Baseband Technology Overview** WINNF-09-P-0009-V1.0.0
Feb 11, 2010	**Use Cases for Cognitive Applications in Public Safety Communications Systems Volume 2** Chemical Plant Explosion Scenario WINNF-09-P-0015-V1.0.0
Jun 01, 2009	**Test and Certification Guide for SDRs based on SCA - Part 1: SCA** SDRF-08-P-0007-V1.0.0
Jun 01, 2009	**Public Safety Radio System Cost Model** SDRF-09-P-0001-V1.0.0
Jun 01, 2009	**Public Safety SDR Lifecycle Cost Estimation Workbook** SDRF-09-P-0001-V1.0.0
Jun 01, 2009	**Use Cases for MLM Language in Modern Wireless Networks** SDRF-08-P-0009-V1.0.0
Jun 01, 2008	**Cognitive Radio Definitions and Nomenclature** SDRF-06-P-0009-V1.0.0
Jun 01, 2008	**Utilization of Software Defined Radio Technology for the 700 MHz Public/Private Partnership** SDRF-08-P-0004-V1.0.0
Jun 01, 2007	**Use Cases for Cognitive Applications in Public Safety Communications Systems - Volume 1: Review of the 7 July Bombing of the London Underground** SDRF-07-P-0019-V1.0.0

- **Volume 2:**
  - Applications, formalization, and role of context
  - Underway
  - Contributors are welcome!

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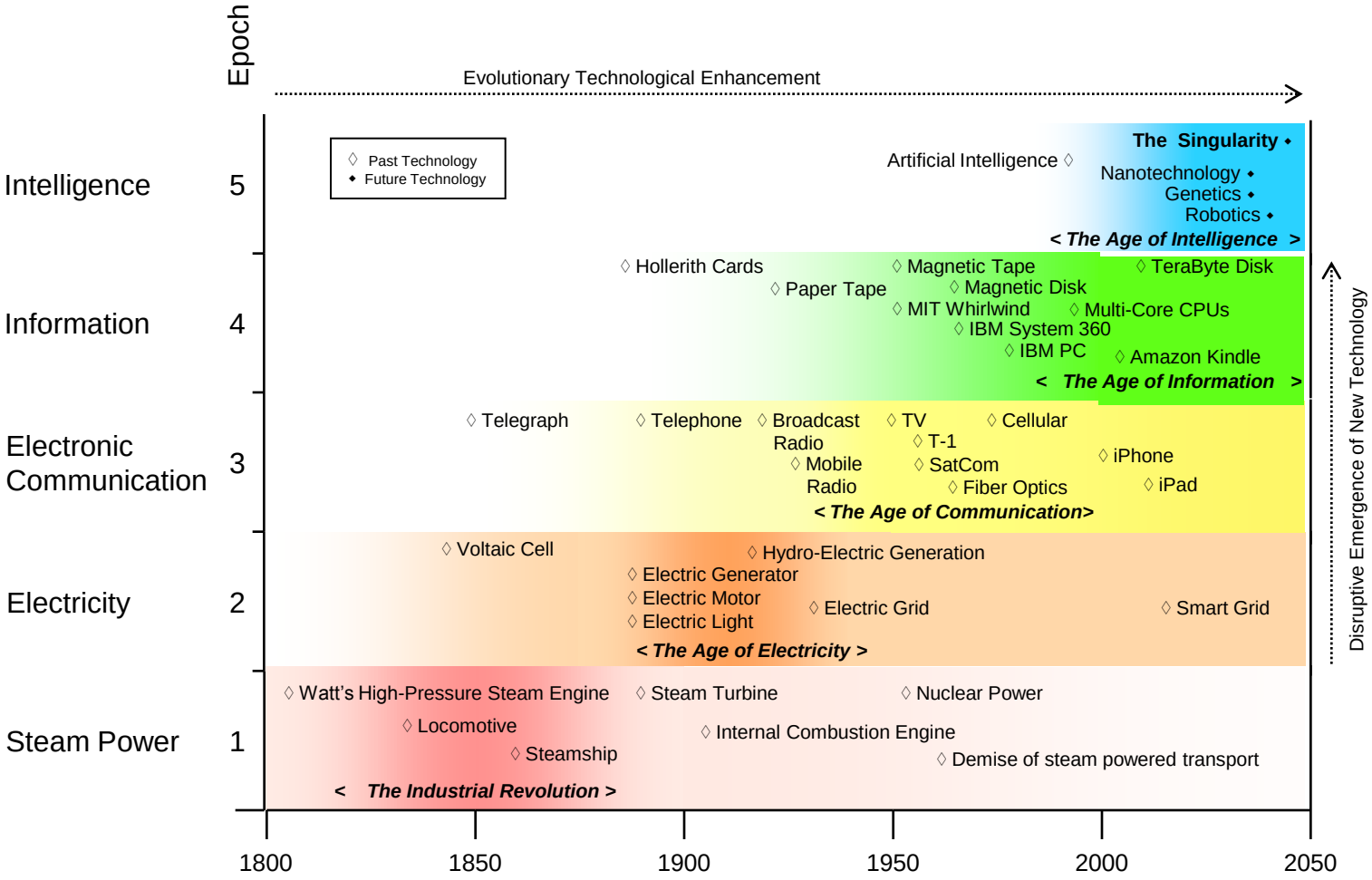
Technology Epochs and Innovations



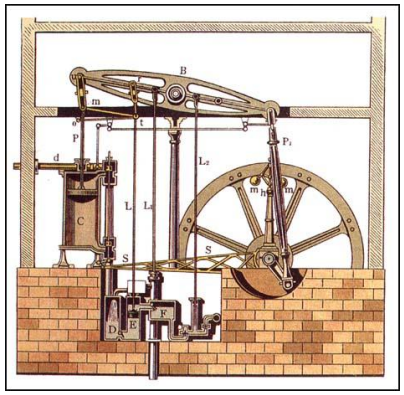
Steam Power

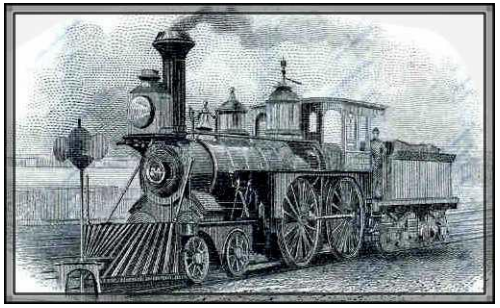
The Technology

- The thermodynamic properties of steam permit introduction of vast amounts of mechanical energy when and where needed, replacing muscle, wind, and water power
- Placing steam engines on steel rails and in ships revolutionizes transportation capacity
- Communications enhanced with rail newspaper distribution

Impact

- Enormous improvement in productivity result from the Industrial Revolution and introduction of machines and factories
- Skilled craftsmen are supplemented with less skilled factory workers performing simpler tasks
- Migration from rural to urban settings

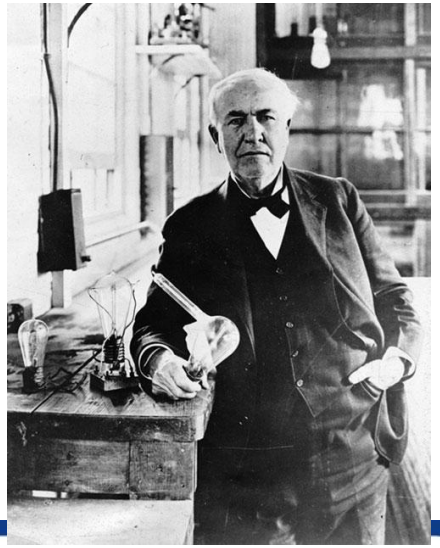




Electricity

The Technology

- Transmission lines transfer energy from large, efficient power plants to point of use
- Fractional horsepower motors deliver energy to point of use
- Electric lamps provide lighting whenever needed
- Automobiles, buses, and trucks enabled by internal combustion engine, but become practical with electric lights and starters



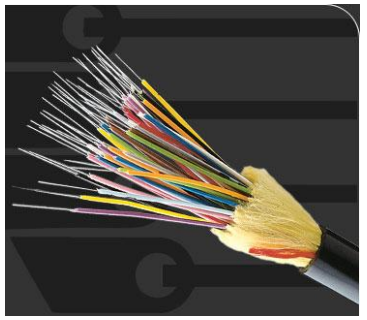
Impact

- Factory efficiency further enhanced; 24-hour operation
- Family life enhanced by improved lighting
- Trolley cars initially effective, but automobile enables suburban society

Electronic Communication

The Technology

- Telegraph, telephone, teletype, and radio permit instantaneous delivery of information over great distances
- Two-way radio makes communication from moving vehicles practical
- Fax and TV deliver visual information
- World-wide fiber optic links provide nearly unlimited landline bandwidth; demand for RF spectrum presents challenges
- Digital integrated circuits and CPUs provide universal instantaneous connectivity

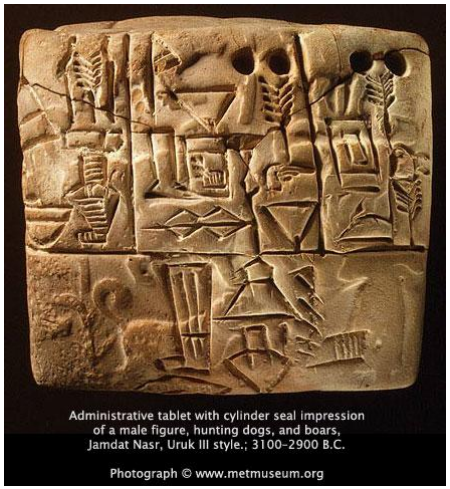


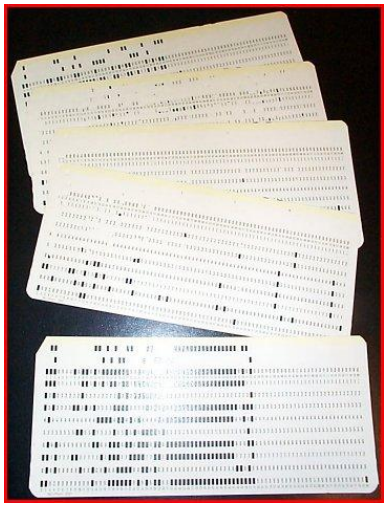
Impact

- Transition from a society based on atoms to one based on bits is started
- Location is no longer a significant factor in commercial transactions

Information: Technology

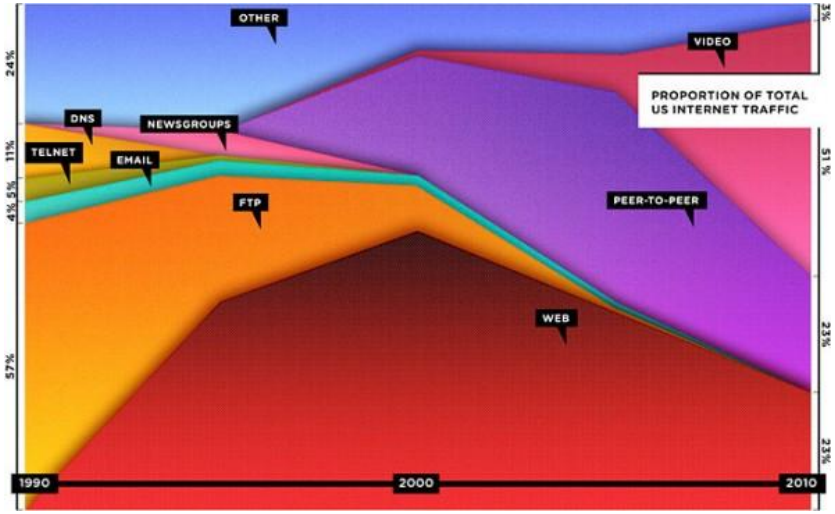
- Speech, writing, printing are past revolutionary information technologies
- Punched cards introduced in 1889 capture information in a form that can be sensed and communicated electrically
- Current IP Systems build on Electronic Communications are able to deliver data worldwide instantaneously; Internet
- Content can be audio, video, text, numbers
- Information results from data taken in context
- The prodigious volume of information handled precludes most human intervention
- BUT the fundamental reason for existence of information systems is to further human goals and interests

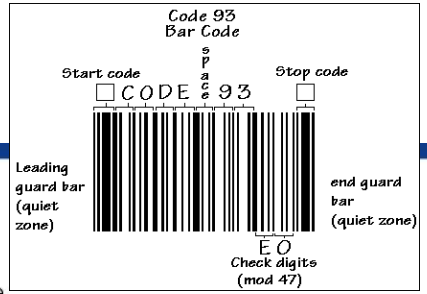




Information: Impact

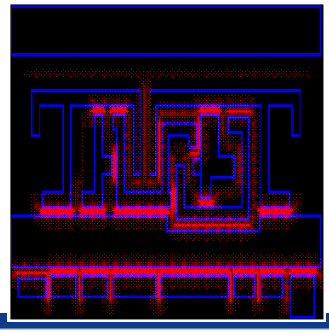
- The information revolution is a work in progress, but it is changing the way we do business and interact personally
  - Postal mail volume down, email prevails (for now), everyone types
  - Newspaper and magazine ads and circulation down
  - eBooks replace printed books, ebook readers are a new market
  - Check images instead of paper returned by bank
  - Paperless credit card transactions
  - Telecommuting, teleconferences reduce travel for face-to-face meetings
  - FaceBook, Twitter, LinkedIn, etc.
- Independently developed legacy information/data processing systems expand, start to intersect, need to overcome silo walls
- Communication systems deliver data; role of context to mature data into information not well understood
- Wireless systems extend network to users in motion, provide universal connectivity





Intelligence: Technology

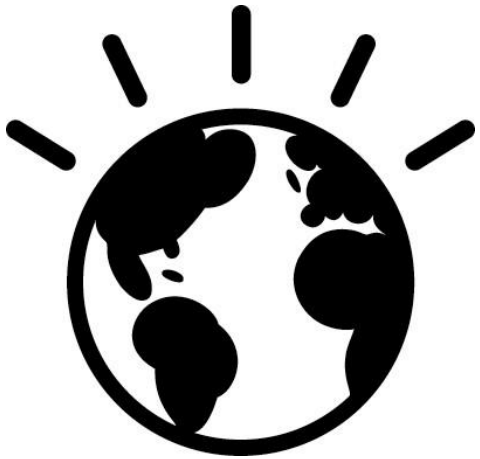
- System processes evolve from user-controlled to autonomous; systems increasingly exhibit cognitive/intelligent behavior
- Systems are able to identify individuals, know where they are; identity theft and other crime become rare
- Universal connectivity, movement globally optimized
- Universal identification of objects; custom manufacturing (economic order quantity (EOQ) approaches one)
- New generations of electronic equipment cannot be built without computer aided design; computers design their future replacement



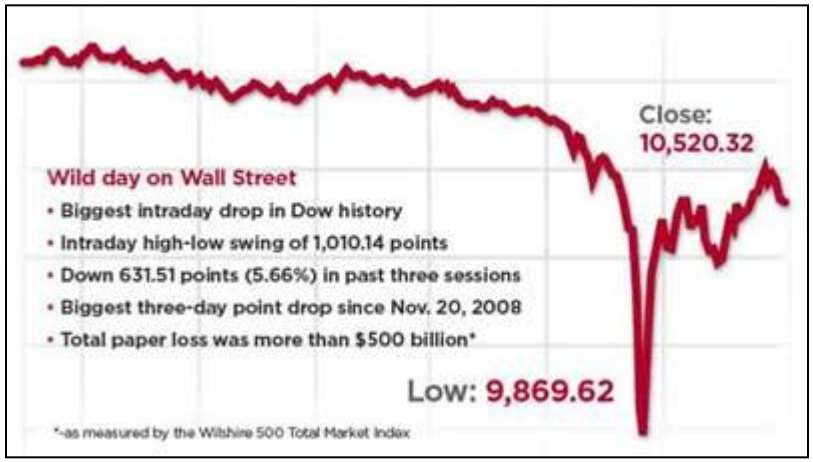
MIT: 6th Sense

Intelligence: Impact

- Looking back over previous technology revolutions provides clues as to what to expect; some things (family life) will be about the same, some (how business is conducted, commuting) will change in ways difficult to predict
- It is imperative that we manage this transition so that automated optimization does not lead to unintended consequences



IBM: Smarter Planet



Flash Crash of May 6, 2010

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IPA Premises and Concepts

- At its inception, WWINNF (formerly SDRF, MMITS) focused on application of SDR concepts to analog voice applications; digital quickly emerged; SDR is now a mature technology
- As digital information systems exhibited exponential growth, communication links became an essential IS component
- The IPA project was started to understand the fundamental characteristics of IS and explore Cognitive Radio concepts
- Preliminary exploration indicates that although DP/IS systems seem to be very different, under scrutiny they have many common processes; many of the differences are superficial, due to different nomenclature and independent development
- Tools for high-level architectural description, staying above implementation details, could have value in managing the intersection of expanding systems and proposed new ones

IPA Goals and Objectives

- **Describe a framework for description of information systems to clearly describe independent aspects to facilitate system description**
- **Describe the fundamental components of IS and their interaction**
- **Identify cycles of information process functionality**
- **Clarify the interaction of User-controlled and Autonomous processes as system cognitive functionality emerges**
- **Understand the critical but often unrecognized role of Context in information system architecture**
- **Bridge the gap between system architectural structure and system engineering**

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System Reference Model

Purpose	Application area, motivation, goals, requirements, and preconditions under which the system operates
Scope	System Boundaries, What is Included in the System
Technology	Underlying technology that enables the System and is used by it, level of technology maturity, evolutionary or disruptive
Economics	Business case for the System, Revenues, Cost structure, who pays, who profits
Politics	Regulatory considerations, public funding, benefits, legislative support, popular support, volatility of support
Structure	Identification of higher-level System, interfaces to and interaction with sibling Systems, process structure, precursor to System design

Purpose

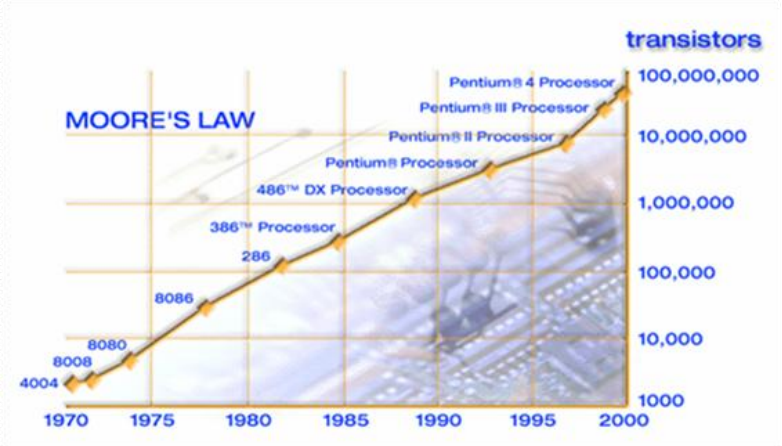
- **Explanation of what the system does**
- **Organization goals furthered by the system**
- **Presentation of system requirements**
- **Understanding underlying assumptions and preconditions**

Scope

- **Explanation of what the system *doesn't* do**
- **Definition of system boundaries and interfaces**
- **Determination of Scope changes resulting from system enhancement**
- **Identification of adjacent systems, recognition of possible overlaps, interfaces, and interaction**

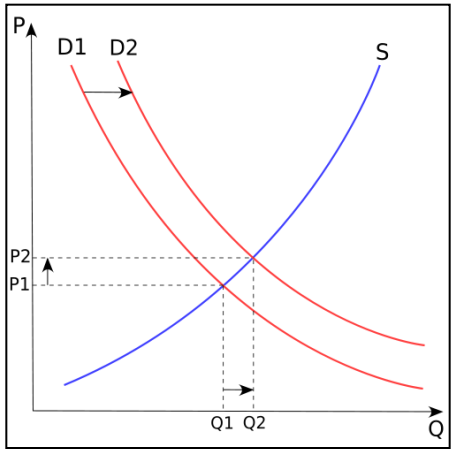
Technology

- **Description of underlying system technologies**
- **Identification of system improvements available through advances in technology**
- **Evaluation of evolutionary and revolutionary technology innovations**



Economics

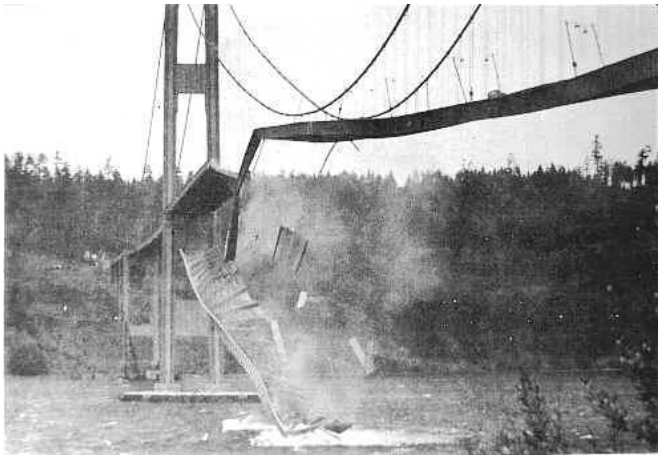
- **Description of the business case**
- **Define economic trade-offs**
- **Determine implementation cost and operating cost**
- **Project revenues for profit-making systems; sources of funding for non-profit systems**
- **Make economic decisions based on complete system life-cycle**



Politics

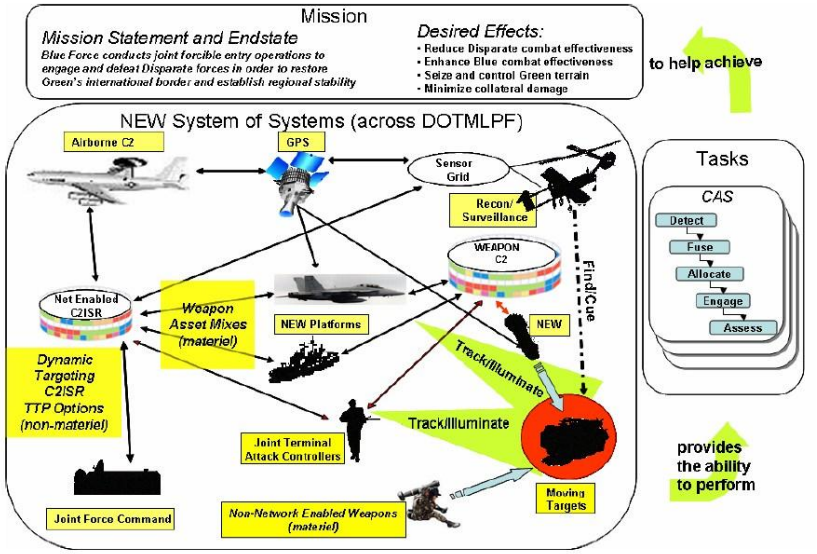
- *Politics is a catch-all category where issues arise due to interaction with the environment; many of them defy modeling or prediction*

- **Applicable law**
- **Regulatory requirements**
- **Impact of executive decisions**
- **Public sentiment**
- **Security determination between level of security and the cost and inconvenience involved**
- **Risk: consequences if the system fails to perform**



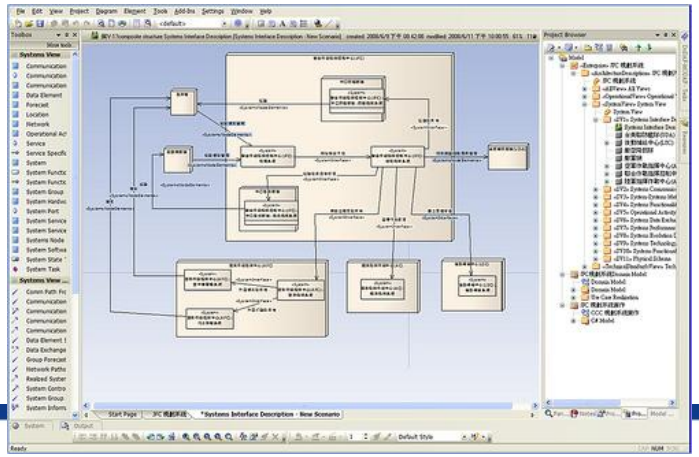
Structure

- **At the architectural level, broad high-level consideration of how the system will function**



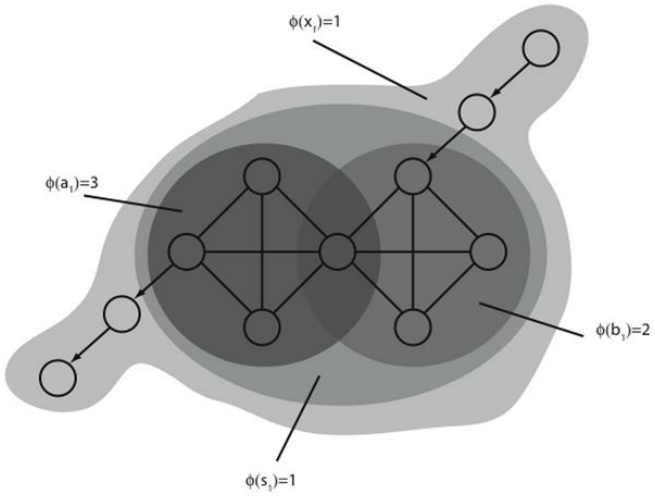
DODAF OV1

- **System engineering and system development will use this Structure for guidance during implementation**



Information System Framework Summary

- **The IPA Framework makes explicit the attributes of Information Systems**
- **It is particularly useful in considering what happens when independently implemented systems with different initial Purpose expand in Scope and start to overlap**
- **Identification of issues and relevant attributes can facilitate their resolution; no amount of Technology can overcome Political obstacles; stable Economics are essential to robust long-term system performance**



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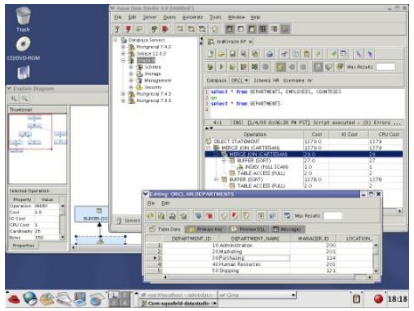
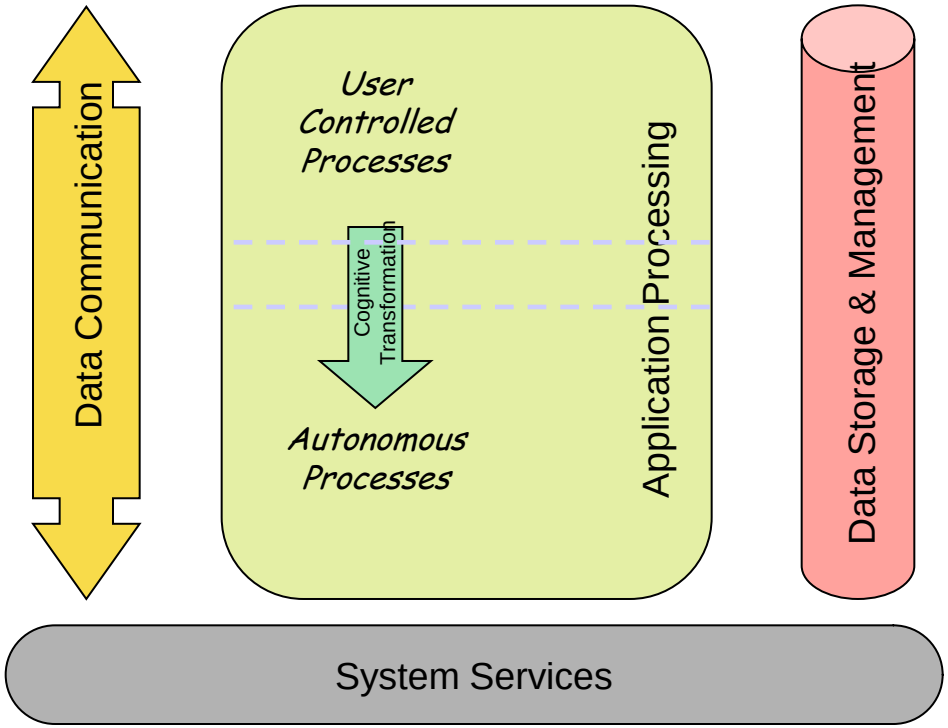
System Elements

- **Systems have common elements**
  - System services, including Operating System
  - Application Processing
  - Data Storage and Management
  - Communications
- **This model considers software only; processes can be operating in the same box or around the world**
- **Operating at a level of abstraction that is hardware independent facilitates system understanding and enhances comparison of very different system types**
- **Common terminology facilitates apparent system differences that are, in fact, the result of differences in terminology and perception**



System Elements



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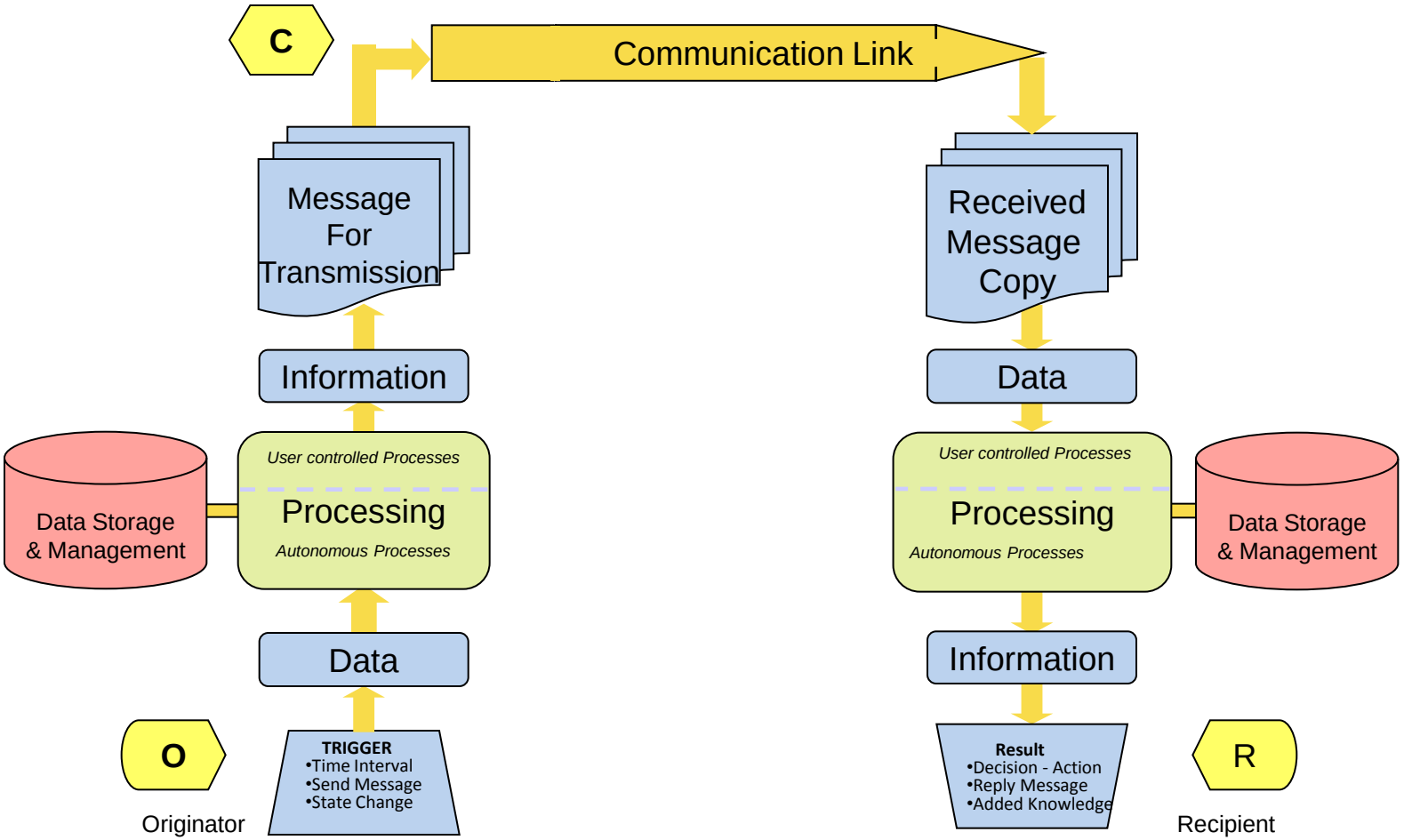
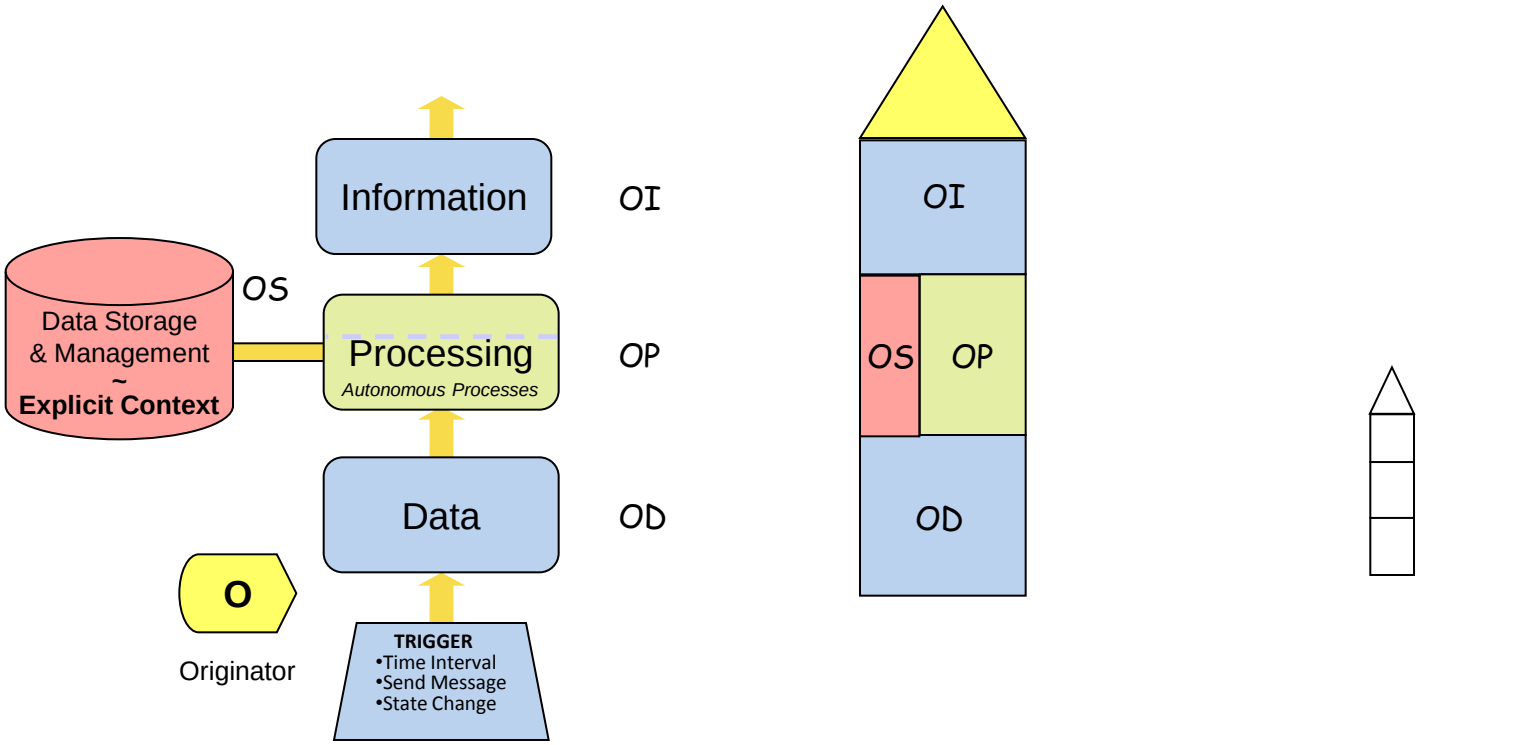
Data ⇨ Information ⇨ Knowledge ⇨ Wisdom

- **Data is a set of symbols reflecting something measured, observed, as implied by a sensor or observer**
- **Information is data taken in context**
- **Knowledge is an accumulation of information and experience ready to be put to work**
- **Wisdom is the effectiveness of knowledge application**

Information System Flow Cycle



Process Flow Diagram: 1) Originator

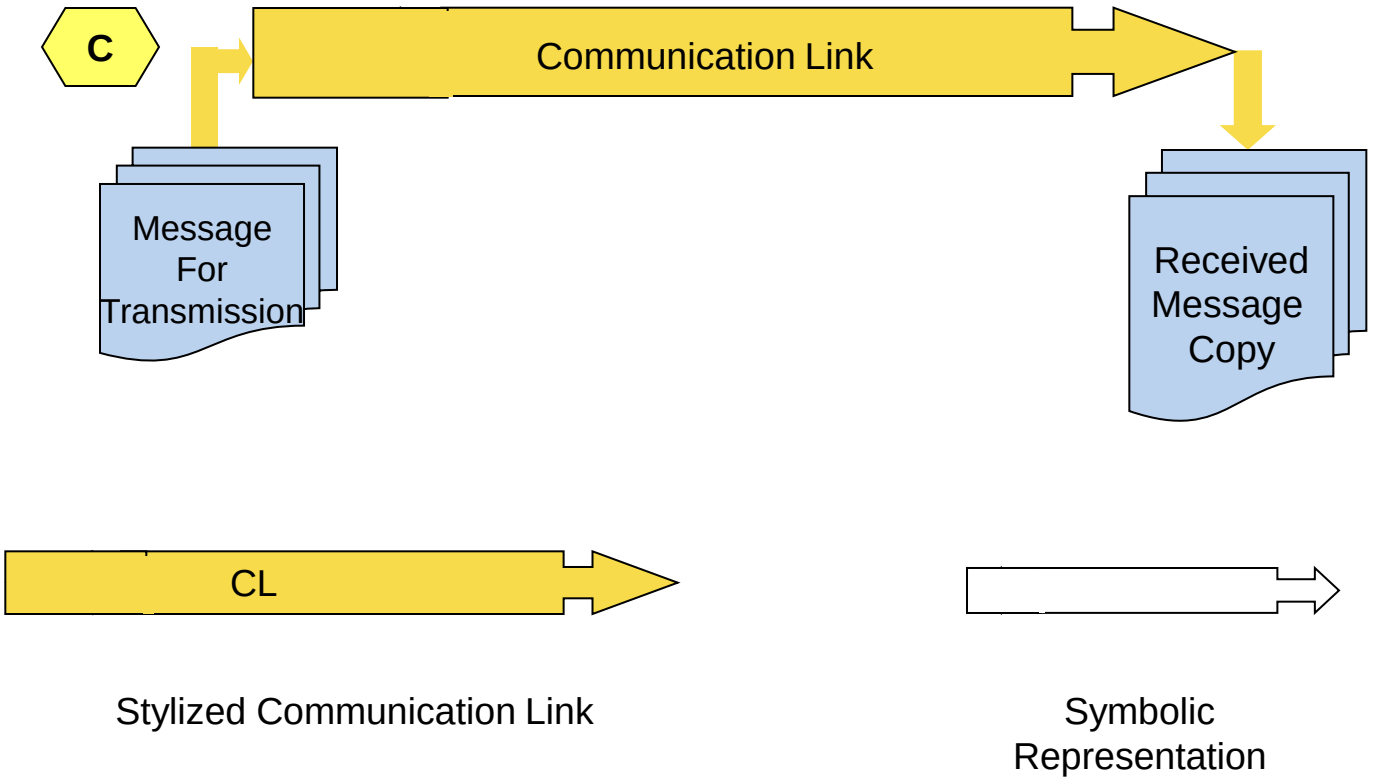


Origination Process From Basic Model

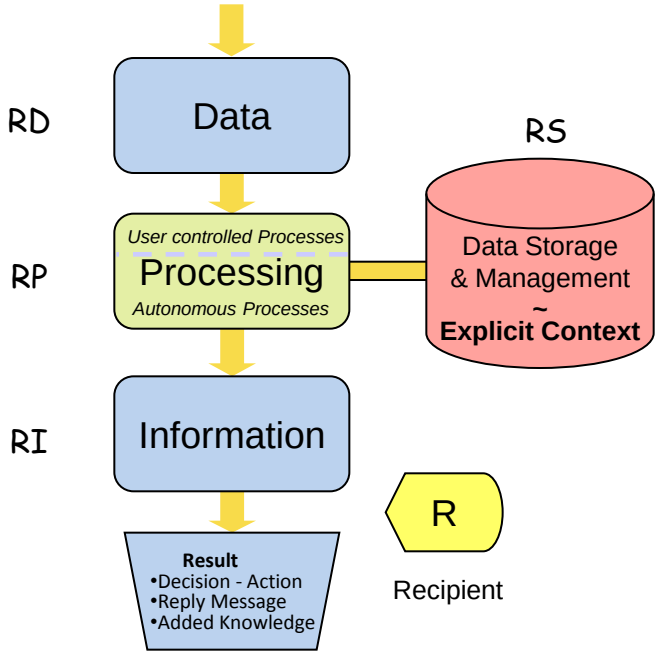
Stylized Origination Process

Symbolic Representation

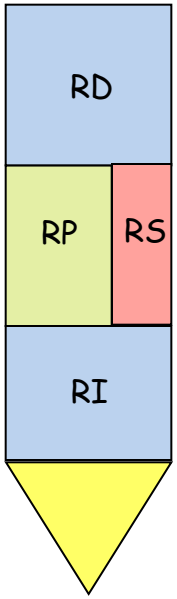
Process Flow Diagram: 2) Communication



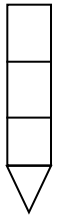
Process Flow Diagram: 3) Recipient



Recipient Process
From Basic Model



Stylized
Recipient Process



Symbolic
Representation

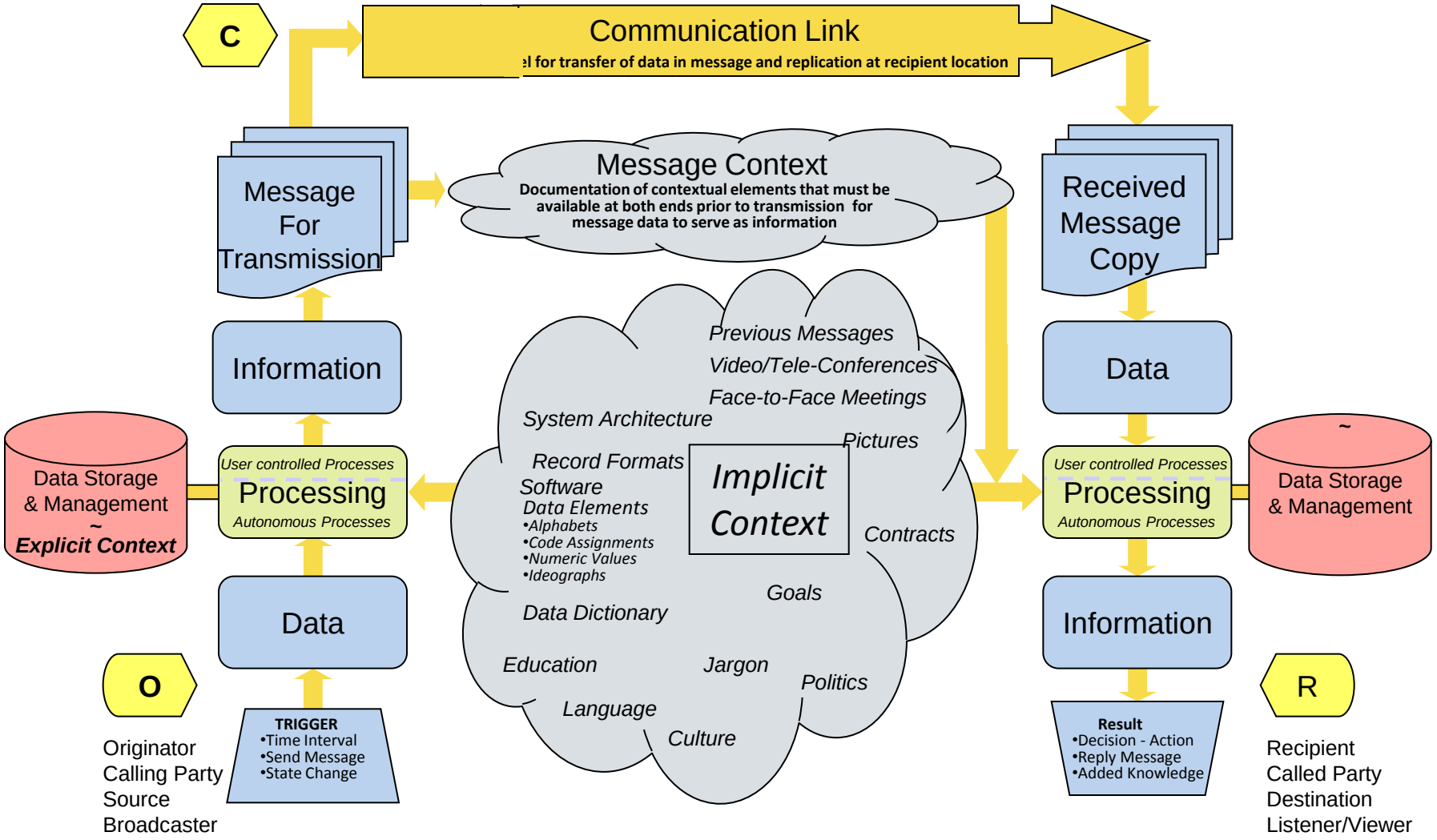
Information System Context

- **Communication links deliver data**
- **Received data quality is a function of channel noise, interference, and attempted subversion**
- **Data must be taken in context to serve as information**
- **Context is often taken for granted; misapplication can lead to erroneous information**
- **More fundamental work is needed on the nature of data, explicit context, implicit context, and resulting information quality**

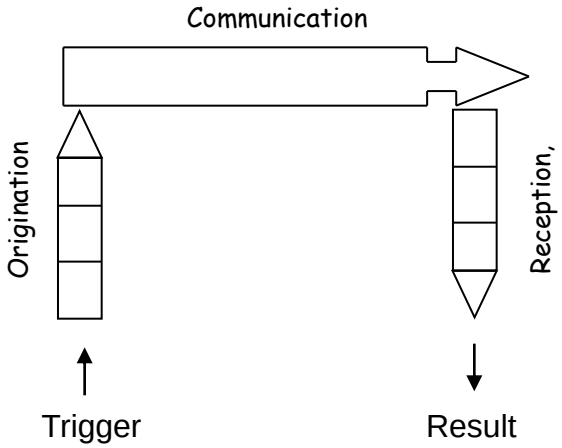
1 bit of data + context

lots of data, but insufficient context

Information System Flow Model with Context



Basic Model Symbolic Representation



Note: Standby is not part of the Basic Model, but is used for an entity in a state to be activated in Originate mode to transmit or by arrival of a communication to be activated in Reception mode to receive.

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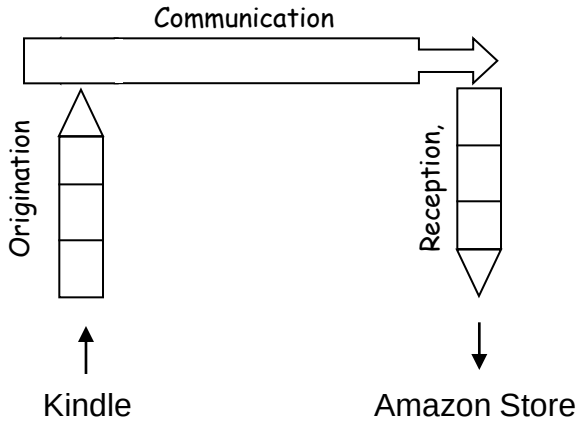
Amazon Kindle Application

Time

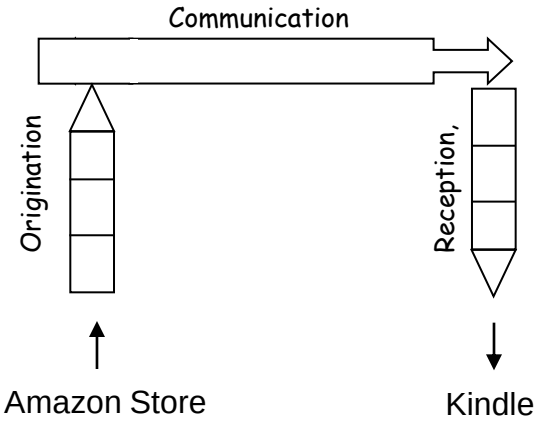
1

Trigger:
- Kindle pressing SELECT
- Chose menu item.



1. Open connection with Kindle Store, request Information.

2

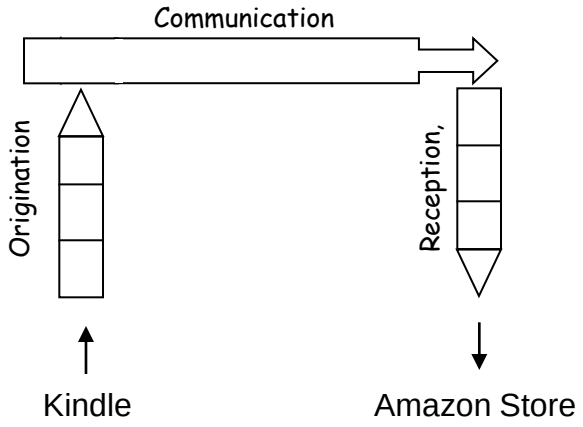


2. Receive catalog information from store, browse, select title

Amazon Kindle Application

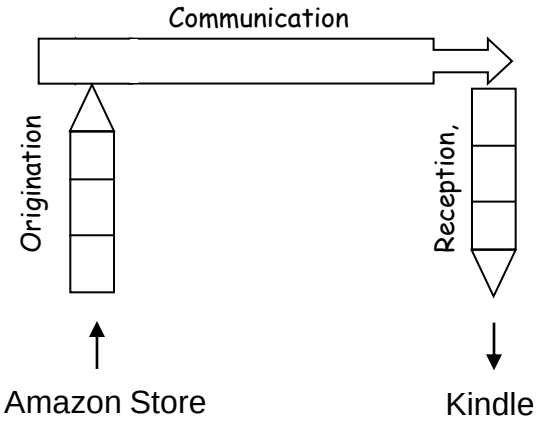
Time

3



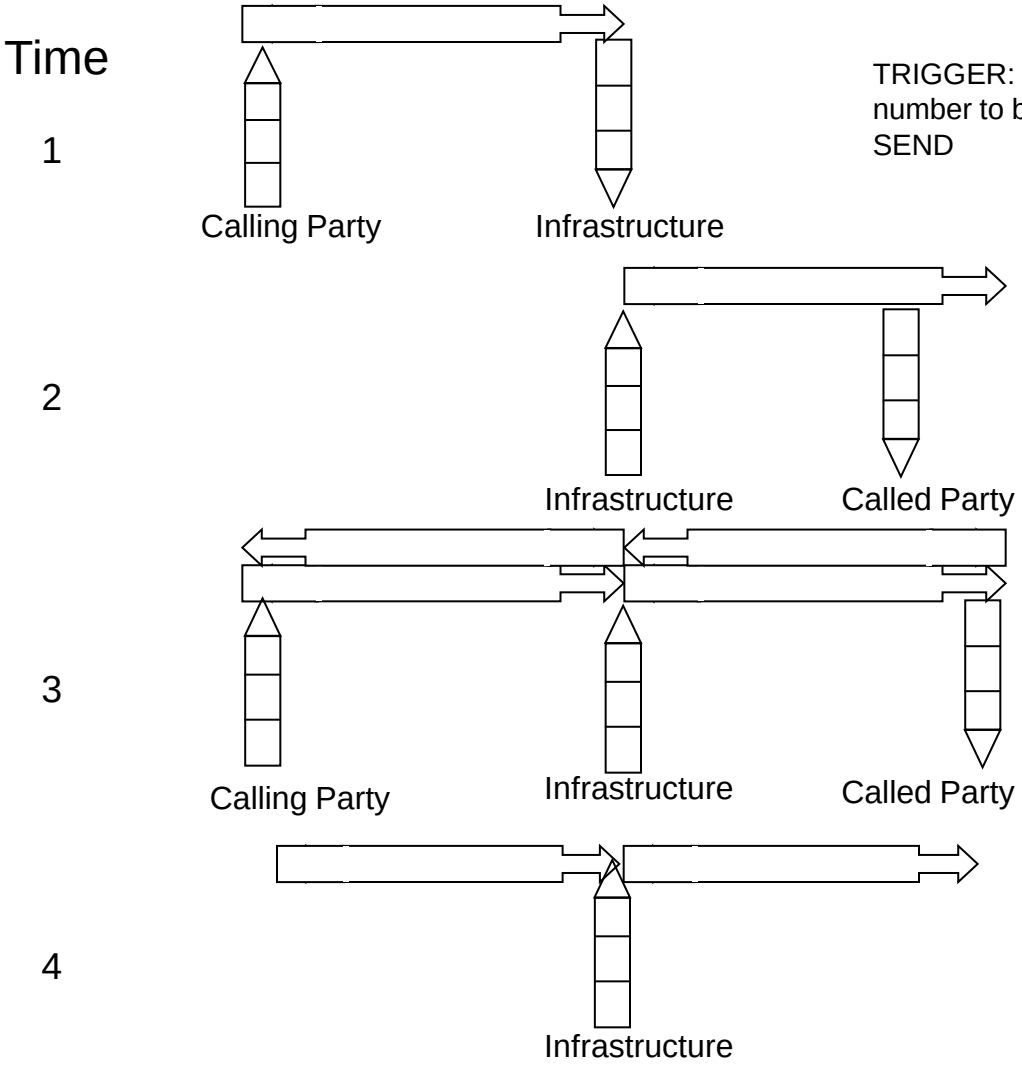
3. Select desired title, request download

4



4. Download book from store to Kindle, place in index

Cell Phone Call



TRIGGER: Calling party enters number to be called, depresses SEND

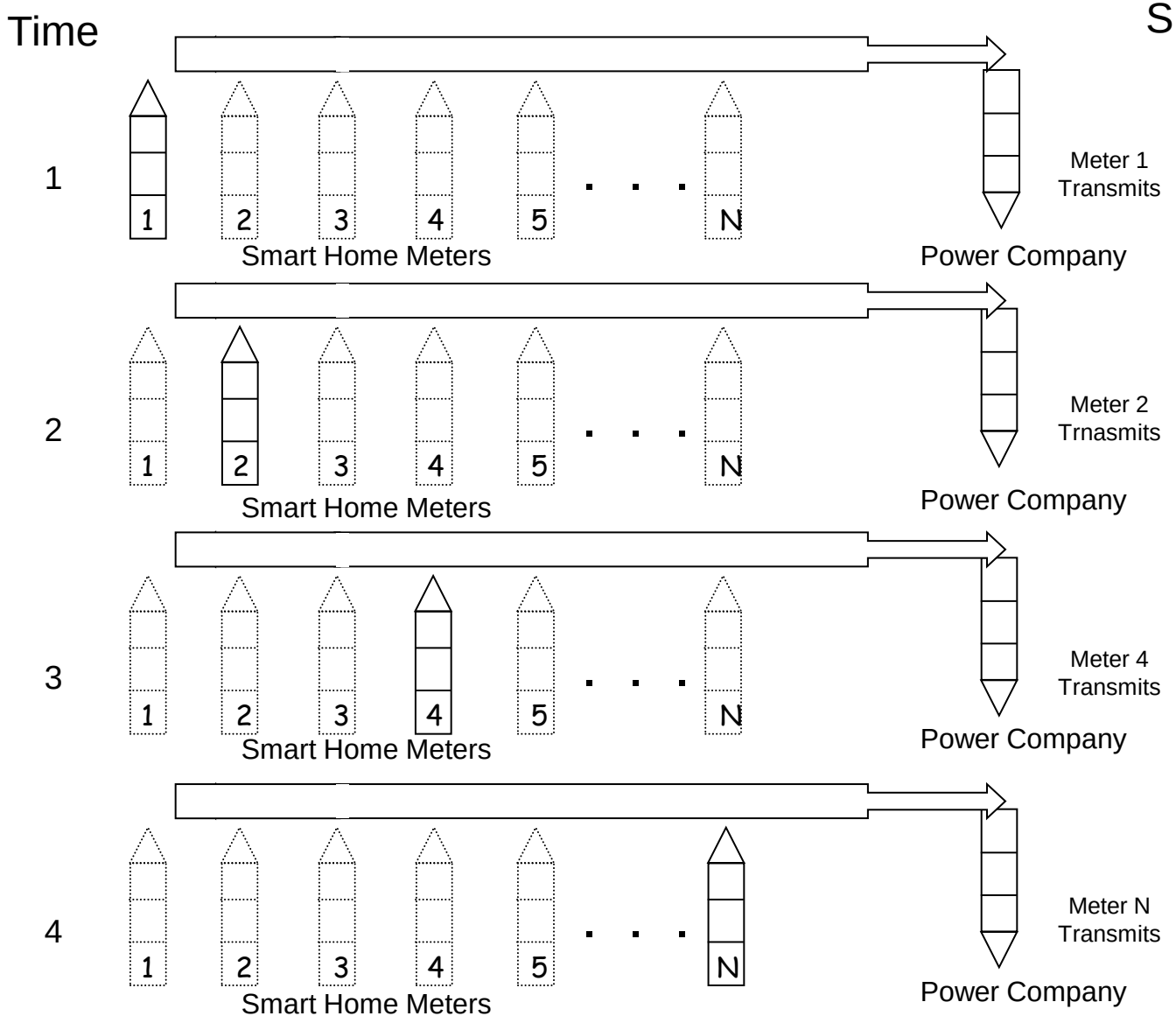
Infrastructure (MSC) checks customer status in HLR, and prepares to set up call

Infrastructure checks called party's HLR for status and location, sets up call ID, and finds RAN from VLR

Infrastructure checks called party's HLR for status and location, sets up call ID, finds RAN from VLR, and activates path for send and receive (full duplex)

Upon call termination, Infrastructure disconnects both parties, tears down call, releases resources, and sends billing information to the accounting system

Smart Grid Meter Reading

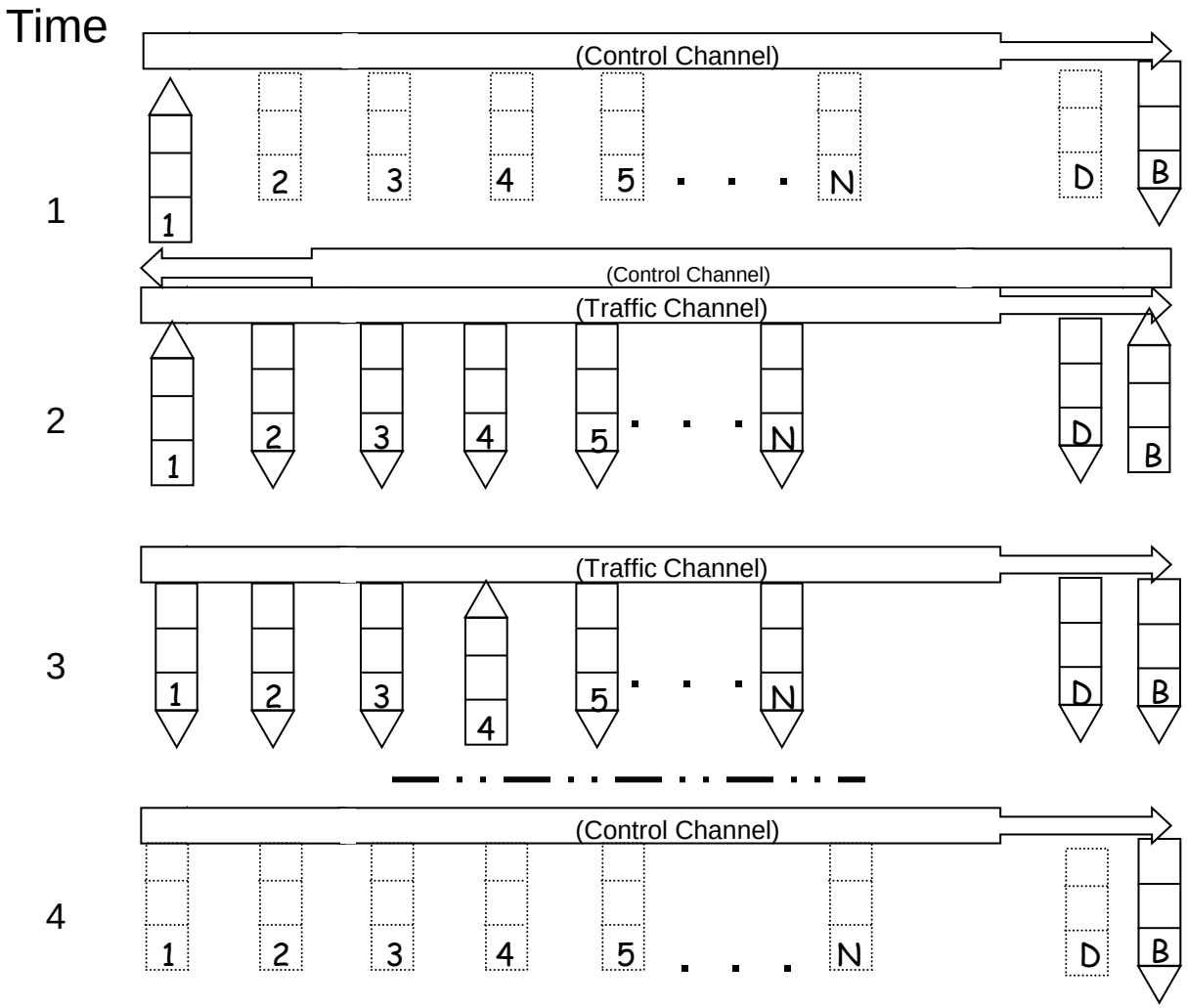


Triggers:

- Elapsed time interval
- Request from Power Co.
- Unexpected change in power load, frequency, other parameters

Each meter transmits
Current power usage
And line parameters
When triggered.

Trunked Mobile Radio Voice



Car 1 presses PTT to initiate message, Cars 2-N are in Standby mode.

Base station controller assigns Traffic channel, commands all Cars to transfer to that channel, Car 1begins to transmit

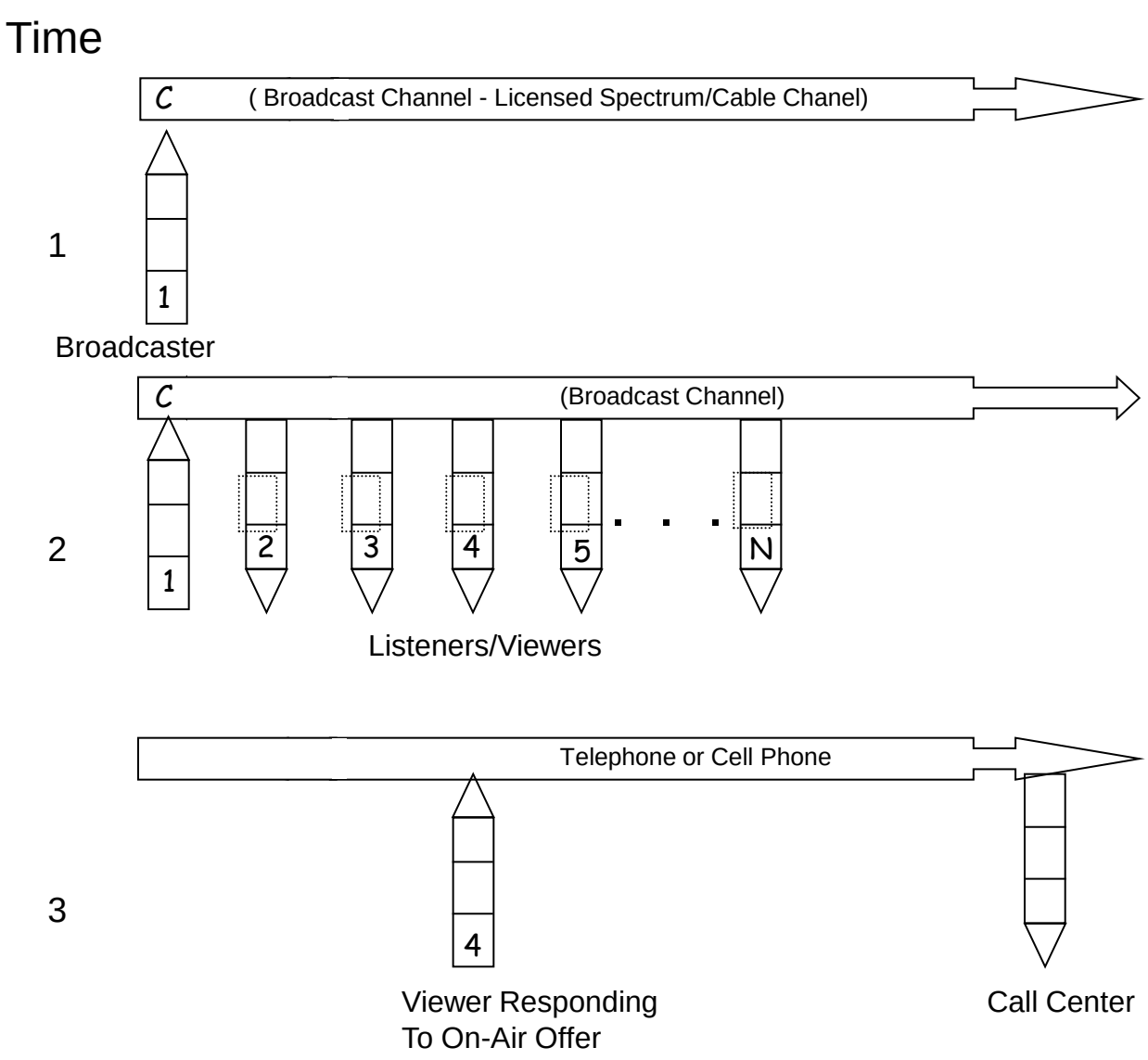
Car 1 completes transmission, Car 4 responds, taking over as transmitting station

When traffic is complete Dispatch and all Cars revert to standby mode

Triggers:

- PTT

Broadcast Radio and TV



Broadcaster obtains License, Acquires Studio and Transmitter; Or contracts for Cable Channel

Owners of receiving equipment tune in to program offerings

Viewers can respond to on-air offerings by commercial Telephone or Cell-Phone

1. Introduction
2. Historical Technology Transitions
3. Key Points
4. Information System Framework
5. Information System Structure
6. Context and Communications
7. Applications
8. Future Work

Future Work

- **IPA Part I has been published**
- **IPA Part II will consist of applying these models and other tools to two specific use cases**
  - Public Safety sensor information integration
  - Electrical Power Smart Grid
- **Both of these cases have numerous subsystems not currently integrated**
- **Working with them will both help understand opportunities for improvement and mature IPA concepts**

	Approved Document WINNF-08-P-0013
Feb 11, 2010	**Commercial Baseband Technology Overview** WINNF-09-P-0009-V1.0.0
Feb 11, 2010	**Use Cases for Cognitive Applications in Public Safety Communications Systems Volume 2** Chemical Plant Explosion Scenario WINNF-09-P-0015-V1.0.0
Jun 01, 2009	**Test and Certification Guide for SDRs based on SCA - Part 1: SCA** SDRF-08-P-0007-V1.0.0
Jun 01, 2009	**Public Safety Radio System Cost Model** SDRF-09-P-0001-V1.0.0
Jun 01, 2009	**Public Safety SDR Lifecycle Cost Estimation Workbook** SDRF-09-P-0001-V1.0.0
Jun 01, 2009	**Use Cases for MLM Language in Modern Wireless Networks** SDRF-08-P-0009-V1.0.0
Jun 01, 2008	**Cognitive Radio Definitions and Nomenclature** SDRF-06-P-0009-V1.0.0
Jun 01, 2008	**Utilization of Software Defined Radio Technology for the 700 MHz Public/Private Partnership** SDRF-08-P-0004-V1.0.0
Jun 01, 2007	**Use Cases for Cognitive Applications in Public Safety Communications Systems - Volume 1: Review of the 7 July Bombing of the London Underground** SDRF-07-P-0019-V1.0.0

In Conclusion

- We are in the midst of an information revolution comparable with historic innovations such as steam power, electricity, telephone, and radio
- The WINNF IPA project intends to explore the fundamental nature of IS, with particular emphasis on the role of wireless communications in system implementation
- IPA is also interested in means by which the intersection of expanding systems developed independently can be managed
- Improved understanding of definitions and functionality of Cognitive Radio is an on-going interest