Architectural Elements for Breaking Boundaries

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Some Intersecting Questions?

- Consider three questions, that might or might not have something to do with each other
  - » If I had "boundaryless information flow," how would I know?
  - » If I had a system-of-systems that had "boundaryless information flow," what would its architecture be?
  - » What is the architecture of the Internet?

- I think there are important common elements in these questions
  - » Asking "What is the architecture of the Internet" leads us to understanding what "architecture" is versus "architecture description"
  - » The Internet's history relates to boundaryless information flow concepts
  - » The lessons, technical and managerial, of the Internet provide key insights

"Boundaryless" Concepts

- Do any of these sound familiar?
  - » Connecting one network to another again and again is tiresome and expensive. Each connection results in its own Interface Control Document and custom applications.
  - » We want to share important applications and information across a diverse set of networks. We can't impose a single approach each of them, they are independently owned and operated.
  - » We want to decouple the development and deployment of applications across networks from the evolution and extension of those networks.

They should…

They are essentially the objectives that led to the Internet in the '70's

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The Architecture of the Internet

- The "organizing structure" is IP
  - » It is the one common point of convergence
  - » The architecture is no less real for not being physical
  - » IP is the subject of documents and code, but it is neither
- The choice of IP is a direct consequence of the main objective
  - » Allow network interconnection without pair-by-pair exchange engineering
  - » But, only unstructured byte block transfer is rendered "boundaryless"
- Collaborative bodies control architecture evolution
  - » IETF, etc.
- Structure repeats in the web

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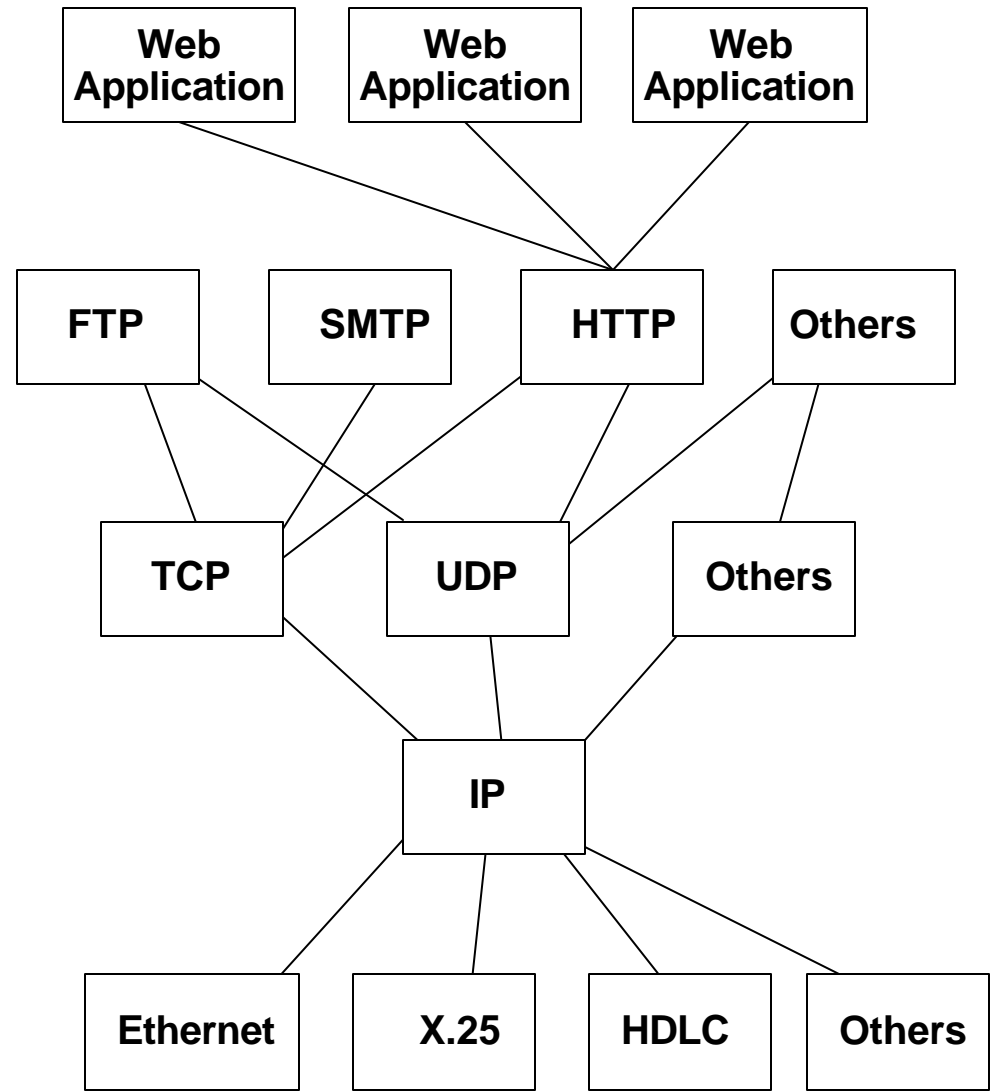
Layers and Objectives

- Historic layered model is ISO/OSI seven layer, reality is 5 to 8 layers
- Relatively strict layered structure is central to Internet choices, and how objectives are met
- Interoperation type is determined by the layer at which convergence takes place
  - » Interoperating applications *must* converge at or above middleware. This *may* be facilitated by lower level convergence
 - » Lower levels help primarily by facilitating data level interconnection

Layer Function	Primary Issues
Provide functionality to users	Meeting user needs with available services
Middleware	Aggregated connections, global name resolution, data representation, multimedia management, security management
Program-to-program data transfer	Connection abstraction, quality of service, congestion control, flow control, program multiplexing, end-to-end error control
Machine-to-machine data transfer	Connection abstraction, quality of service, congestion control, network routing, network control
Point-to-point block data transfer	Framing, error detection-control, multiple access
Point-to-point bit or byte transmission	Modulation, coding

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IETF, Architecture, and Description

- Logical organization, managerial organization are complementary

- Internet Engineering Task Force (IETF) reflects collaborative nature of the Internet
  - » Physical elements are independently owned and operated (Collaborative System or System-of-Systems)
  - » Organizationally formed by codification of de-facto standards, explicit operating roles that foster collaborative solutions over dictated

- IETF publishes de-facto standards (the RFC's)
  - » Publications are not the architecture, they describe the key partitioning decisions
    - – The IP document isn't IP, IP is a protocol
  - » RFC's are the description, the protocol structure is the architecture
  - » Compare to other successful standards (e.g. MPEG, GSM)

Is This an Architecture?

USCENTCOM Deep Operations in the Joint Operations Area
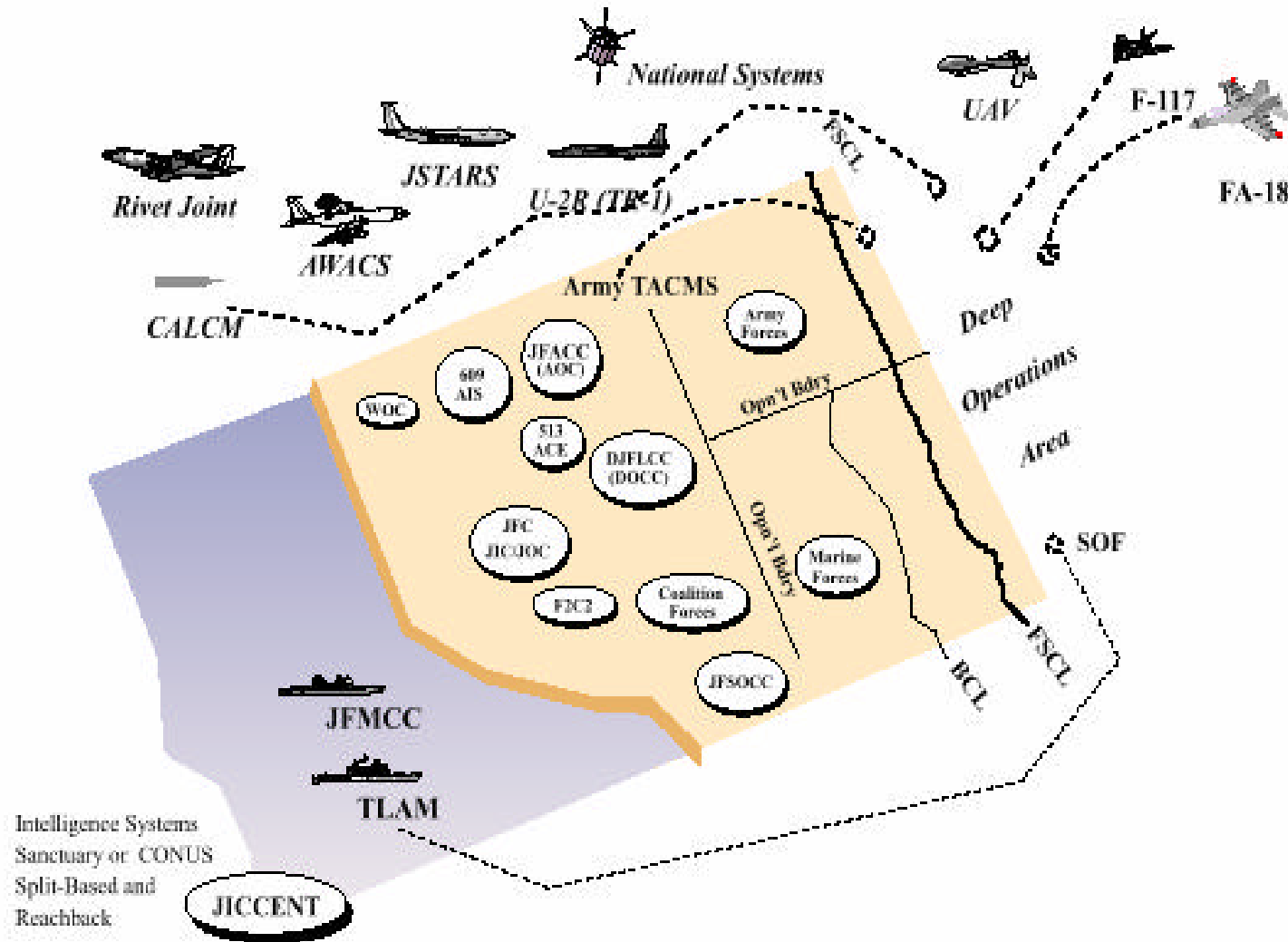
No, It Isn't

- **At Best…**
  - » It is one view of an architecture
  - » It represents the entire system from the perspective of a set of related concerns

- **More Likely…**
  - » It is one model that might be composed with others to make a view
  - » Hopefully it can be thought of as a simplification (in a strict sense) of a more complete description element

- **At Worst…**
  - » It is a cartoon
  - » It makes some managers feel good but that carries no information that can be transferred between phases or groups in development

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Key Lessons

- The bigger the system, the smaller the architecture

  » Internet, family-of-system, effective standards examples

- Architectures provide interoperation, not architecture descriptions

  » Don't expect a document/product driven process to change architectures

  » Writing a description isn't developing an architecture

- Collaborative systems need collaborative architectures and collaboration-enhancing processes

- Standards for architectures and standards for architecture descriptions aren't the same, and don't fulfill the same purpose

For More Information

- Some of my books/papers
  - » The Art of Systems Architecting, Second Edition, Maier and Rechtin, CRC Press, 2000
  - » Architecting Principles for Systems of Systems, Systems Engineering, Journal of INCOSE, 1:4, 1998

- IEEE Architecture Working Group websites:
  - » http://www.pithecanthropus.com/~awg

- IEEE 1471 Interest Group mailing list

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