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An Automated Information Asset Tracking Methodology to Enable Timely Cyber Incident Mission Impact Assessment (CIMIA)

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13th International Command and Control Research and Technology Symposia (ICCRTS)
Bellevue, WA
June 17-19, 2008

Research Sponsors:
Air Force Research Laboratory (AFRL/RHX)

UNCLASSIFIED

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Overview

- Research Motivation
- Background
- Information is an Asset
- Tracking Information Assets
- Conclusions

Research Motivation

Consider the following hypothetical scenario:

- In Iraq, coalition partners are provided connectivity to a US Secret level network for information sharing purposes
- A breach of a coalition partners system occurs
- The breach is detected and stopped
- The breach enabled the adversary to access a server which contains multiple databases
- One of the DBs contains convoy routes and schedules
- The Incident Response Team begins their investigation
- IRT works with the system custodians to identify and notify all information owners / consumers
- The process takes days to complete...

Meanwhile, the Next Day

Background

- Virtually every organization is dependent upon information accessed/stored/processed in cyberspace
- Despite our best efforts at developing defensive capabilities, cyber incidents are inevitable
- Cyber dependence introduces <u>significant</u> risk to both cyber-assets and real-world operations
- Commanders need accurate and timely damage assessment <u>in terms of their Mission</u>
- This is not a new development (RAND Report, 1995)
- We have failed to account for the value of <u>information</u>
- We don't collect, document, and refine knowledge of mission-to-information dependencies effectively!

Prior Research

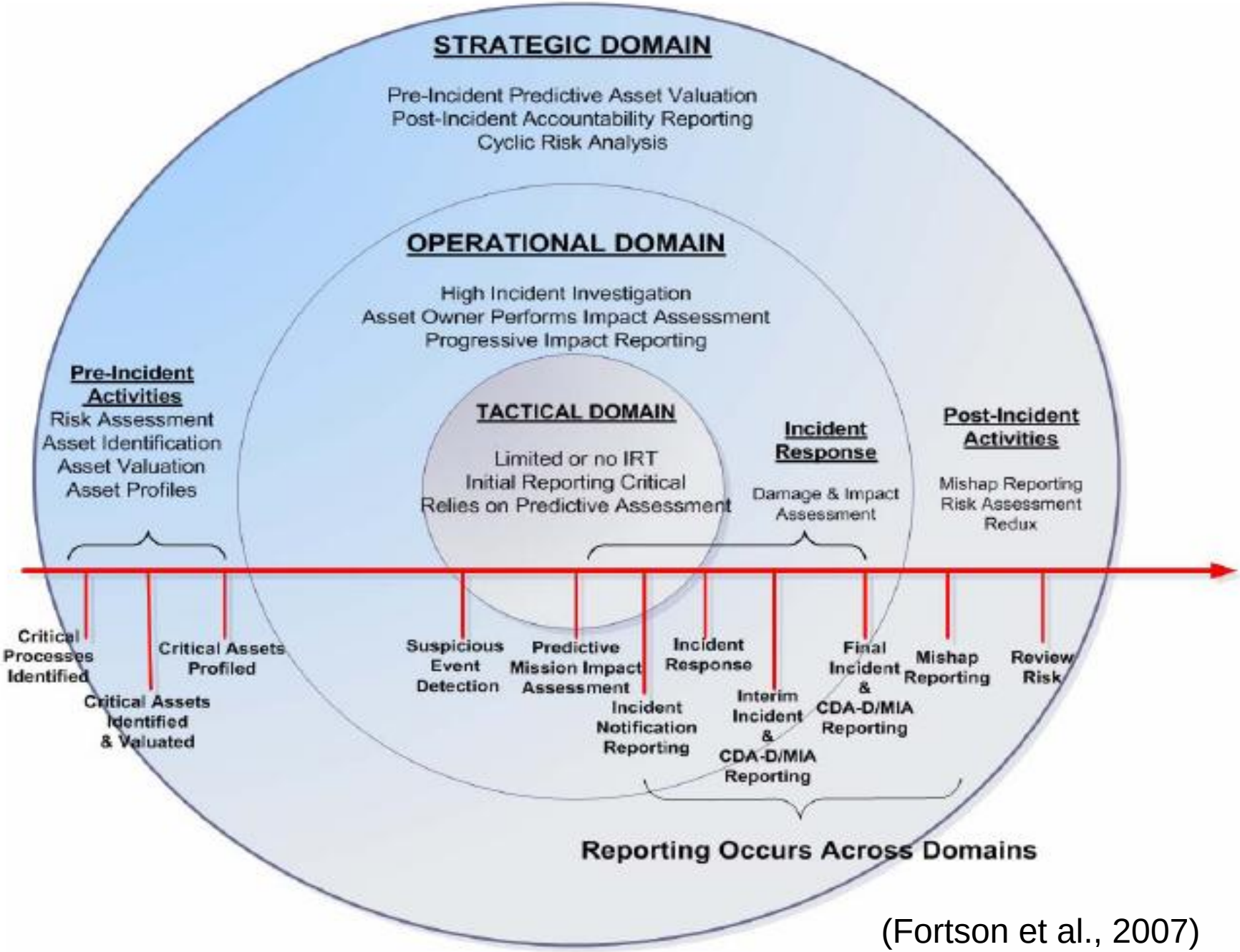
- RAND Report (1995) – The Day After Exercises
- Lala and Panda (2001) – Database damage assessment
- Thiem (2005) – Lack of standardized AF damage assessment methodologies
- Stanley (2005) – Mission impact analysis of communication link state availability
- Wong-Jiru (2006) – Net centric operations model for holistic view of mission dependencies between entities
- Shaw (2007) – Model of network outages in CAOC
- Fortson (2007) – Proposed defensive Cyber Damage Assessment (CDA-D) methodology
- Hellesen (2008) – Proposed an information valuation schema
- Sorrels (2008) – Proposed a system architecture for Cyber Incident Mission Impact Assessment

Key Problems Identified

- Focus on infrastructure protection
- Lack of a formal, standardized risk assessment
- Lack of documentation explicitly identifying:
  - Information Assets
  - Information Valuation
  - Mission / Information Dependencies
- Dynamic nature of missions and organizations
- Lack of timely notification of information consumers following cyber incidents
- Lack of an appreciation for potential impacts
- Lack of accountability
- Lack of after action follow-up

Risk Assessment

- Risk Assessment provides the information required for accurate and timely mission impact assessment
- Risk Assessment requires the identification and documentation of critical organizational resources
- Criticality is determined by how a given resource supports the organizational mission
- The valuation of any resource is:
  - Frame of reference dependent
  - Temporally dependent upon the mission(s)
  - Inherently subjective
- Risk = (Threats ∩ Vulnerabilities)*Probability*Loss
- Allows for a racking and stacking of the risks



(Fortson et al., 2007)

Impediments to Risk Assessment

- Conducting a documented risk assessment is:
  - Labor intensive
  - Time consuming
  - Must periodically be revisited (maintenance)
- Organizations and resources are dynamic entities
- Several different organizations may access and depend upon a resource (hard to estimate value)
- Buy-in from commander is needed to insure compliance and accountability
- Knowledgeable personnel must value resources
- Security aspects of critical asset identification
- Social barriers

Cyber Incident Mission Impact Assessment (CIMIA) Project

Provide decision makers near real-time situational awareness of mission impact following cyber incidents

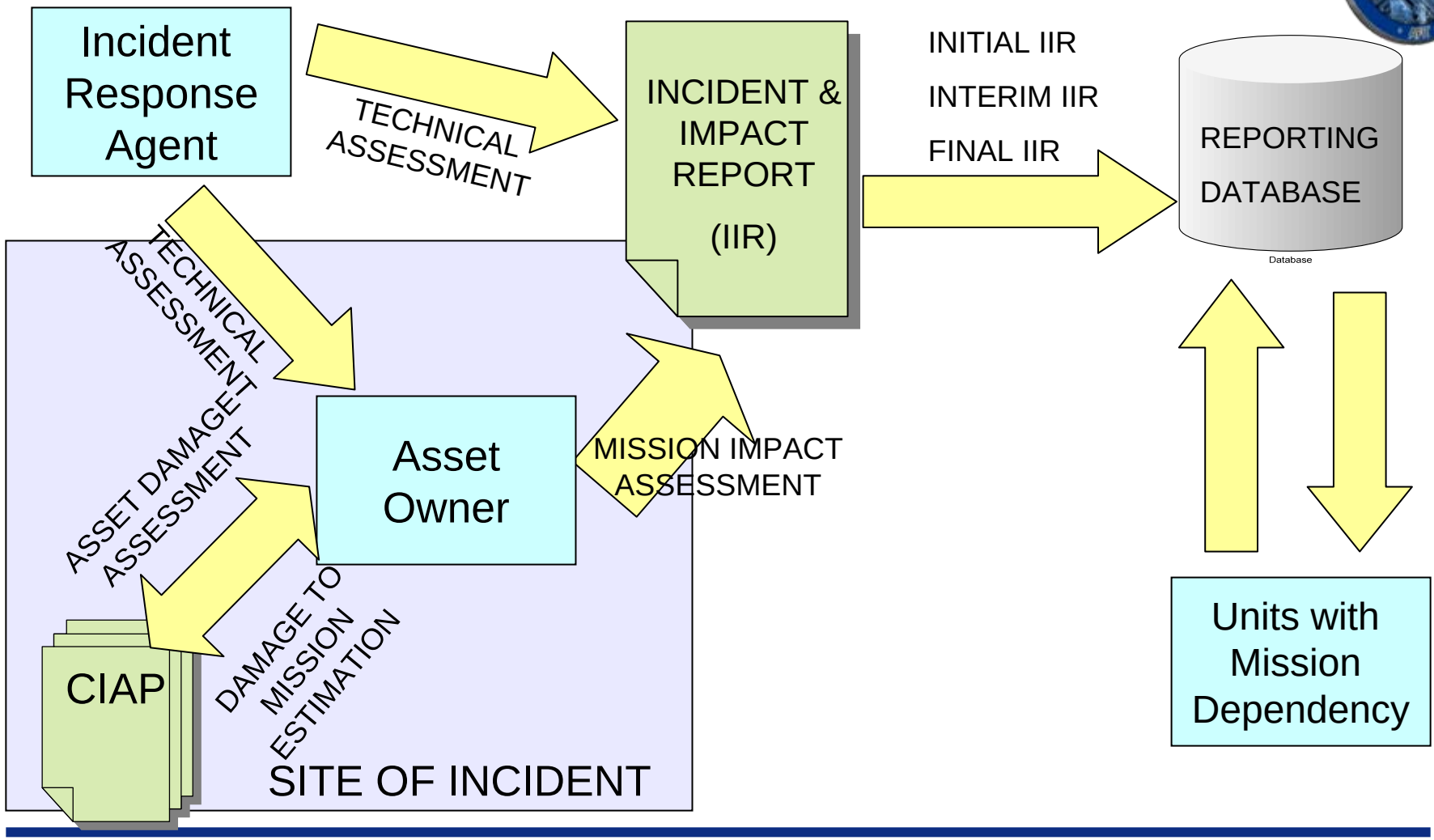
<u>Foundations:</u>

- **Mission operations focus**
- **Holistic approach to mission impact assessment**
  - **Confidentiality, integrity, and availability**
- **Requires a chain of interdependent activities:**
  - **Information asset identification**
  - **Information asset valuation**
  - **Technical (IRT) damage assessment**
  - **Damage-to-mission impact mapping**
  - **Mission impact reporting**

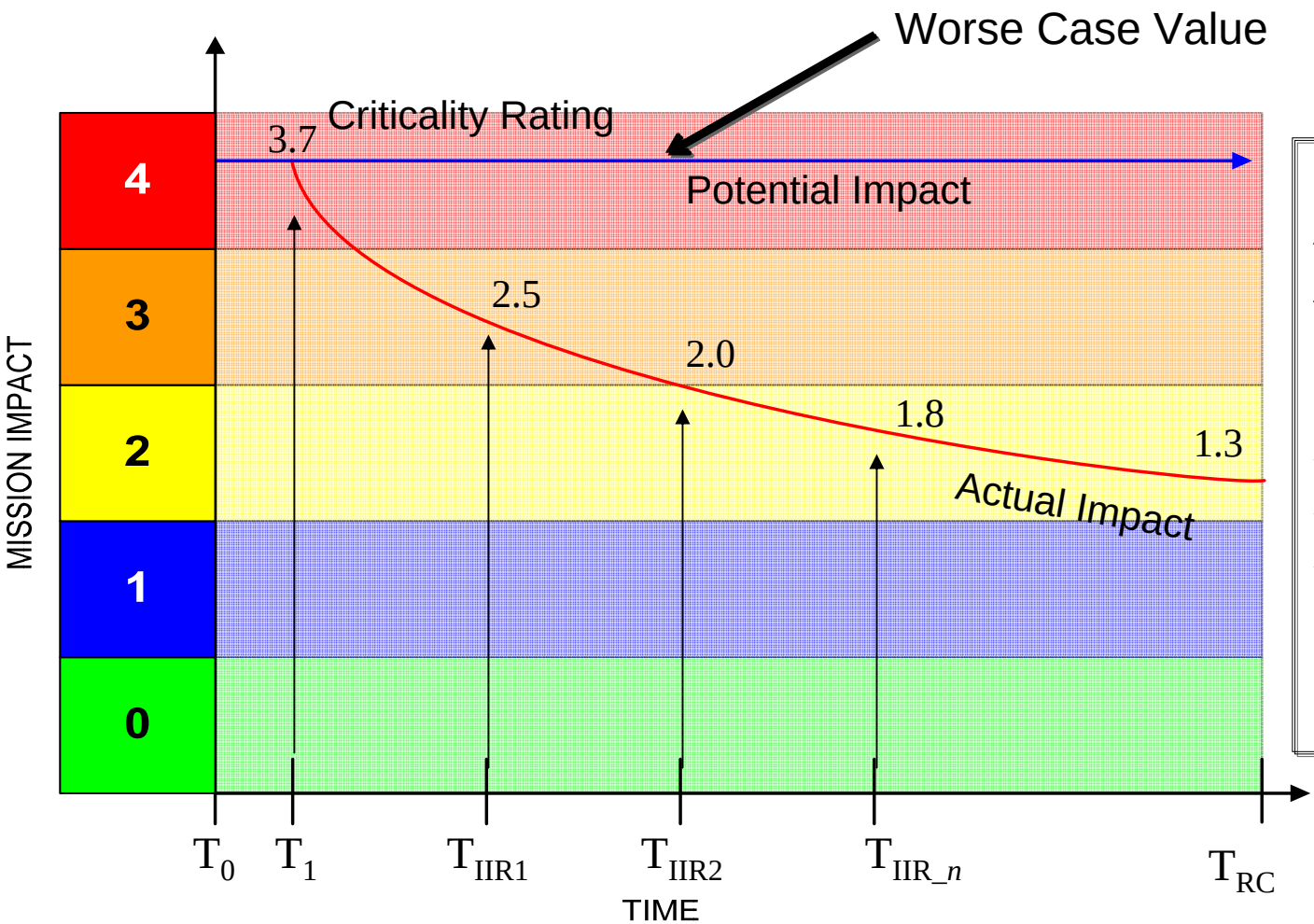
CIMIA Goals

- Notification of all downstream information consumers when an incident occurs
- Mission impact assessment from incident declaration (estimated) through remediation (actual)
- Mapping of mission processes to information assets
- Temporal mission information valuation models
  - Learn historical mission patterns
- Enforce:
  - Accountability / Documentation / Secrecy
- Exploit:
  - Automation to the extent possible
- Explore non-traditional mechanisms

Conceptual CIMIA Reporting



Mission Impact Estimation as a Function of Time



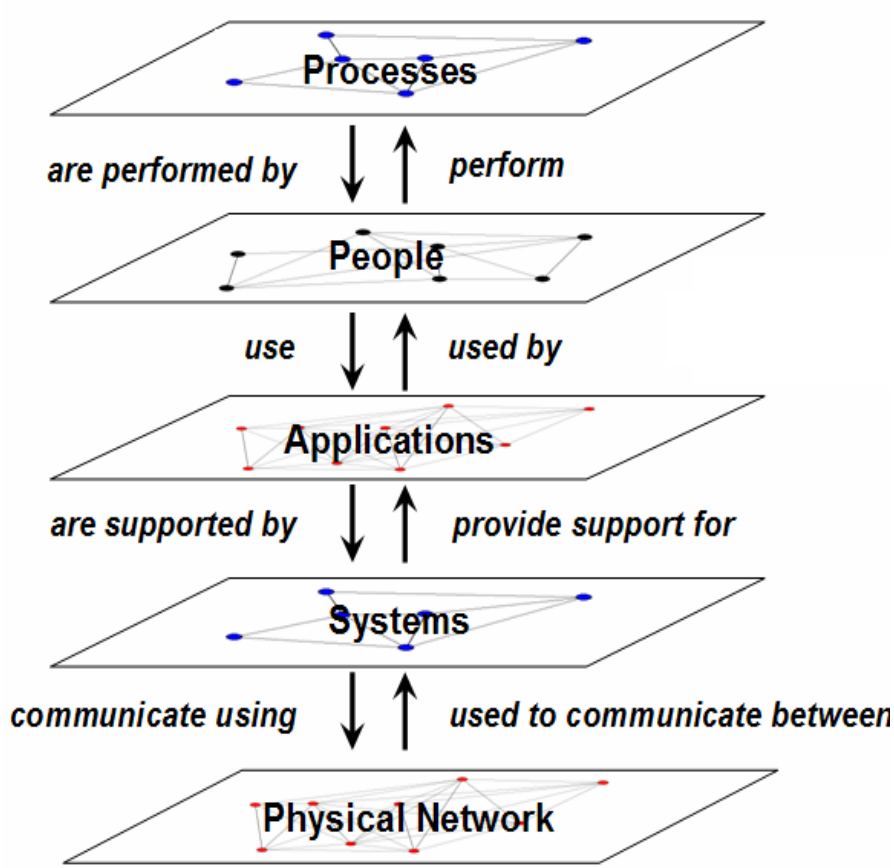
Impact Summary:

A confirmed data spill at Mosul NCC has resulted in the following compromised mission supporting systems:

System	Est	Mission
XXXX1	4	UAV Feed
XXXX3	4	Convoy Mvmnt
XXXX11	3	Personnel Data
…	…	…
…	…	…

Mission Mapping Abstractions

- How to best map mission to underlying resource dependencies?
- How to represent the "value" provided by each intermediate resource?
- What is necessary and feasible to collect and maintain in a mapping?
- How to insure an adversary cannot access and exploit this information?



A Paradigm Shift

- Information is THE asset in cyberspace
- Each organization has a different valuation “lens” through which they view information assets
- The true value of an information asset can only be determined by summation of each consumers valuation using a common measurement scheme
- System focused methods (e.g., DIACAP) do not:
  - Account for all the value consumers derive from accessing information on the system
  - Dynamically update as information assets are added/removed

Information Asset

- A specific grouping of data which provides value
- The granularity is user definable
  - Coarse: All information contained in a system
  - Fine: A specific field within a specific database within a system
- Multiple information assets may reside within the same information container
- The information asset must be uniquely identifiable across the enterprise
- Multiple information assets may be repackaged with other information, creating a new information asset (e.g., intelligence reports)
- How can we manage our information assets?

Information Sources (Providers)

- Any network addressable node that sources (provides) information assets upon request
- Information sources are uniquely identified by the triple containing at least:
  - <IP address , Port number , Resource number>
- Resource number is a locally assigned system resource identifier
- An information source can contain multiple information assets
- Information sources “know” the entities who make requests for information assets
- Example: Weather reports provided by a web server

Information Sinks (Consumers)

- Any network addressable node that receives an information asset and sinks (consumes) it
- Information consumers are uniquely identified by the triple containing at least:
  - <IP address, Port number, Consumer number>
- Consumer number is a local organizational entity identifier (e.g., individual, agent, process)
- There can be multiple consumers present simultaneously on a system
- Information sinks know from whom they received information assets
- Example: A web browser application being run by the weather officer in a Air Operations Center

Information Asset Tag

- Each information asset has an enterprise-wide key ("tag") which is used to uniquely identify it
- The "tag" is a pointer into a database which contains metadata about the information asset
- When an information asset is moved, the tag moves
- Tagging of information assets enables the tracking of the assets from the source (provider), through the infrastructure elements, to the sink (consumer)
  - Accountability can be enforced
  - Network traffic can be prioritized
  - Mission specific patterns can be identified

Information Asset Database

- **A database containing information about the given information asset from the owners perspective:**

  - Key “Tag”
  - Owner
  - Producer
  - Provider
  - Pedigree
  - Age
  - Comments
  - Composite elements
  - Confidentiality Sensitivity
  - Integrity Sensitivity
  - Availability Sensitivity
  - Rated Criticality
  - Derived Criticality
  - Last update

- **Maintained by a central authority (e.g., JTF-GNO)**
- **Global database located in a higher classification network only accessible by authorized entities**

Fictional Information Asset Database

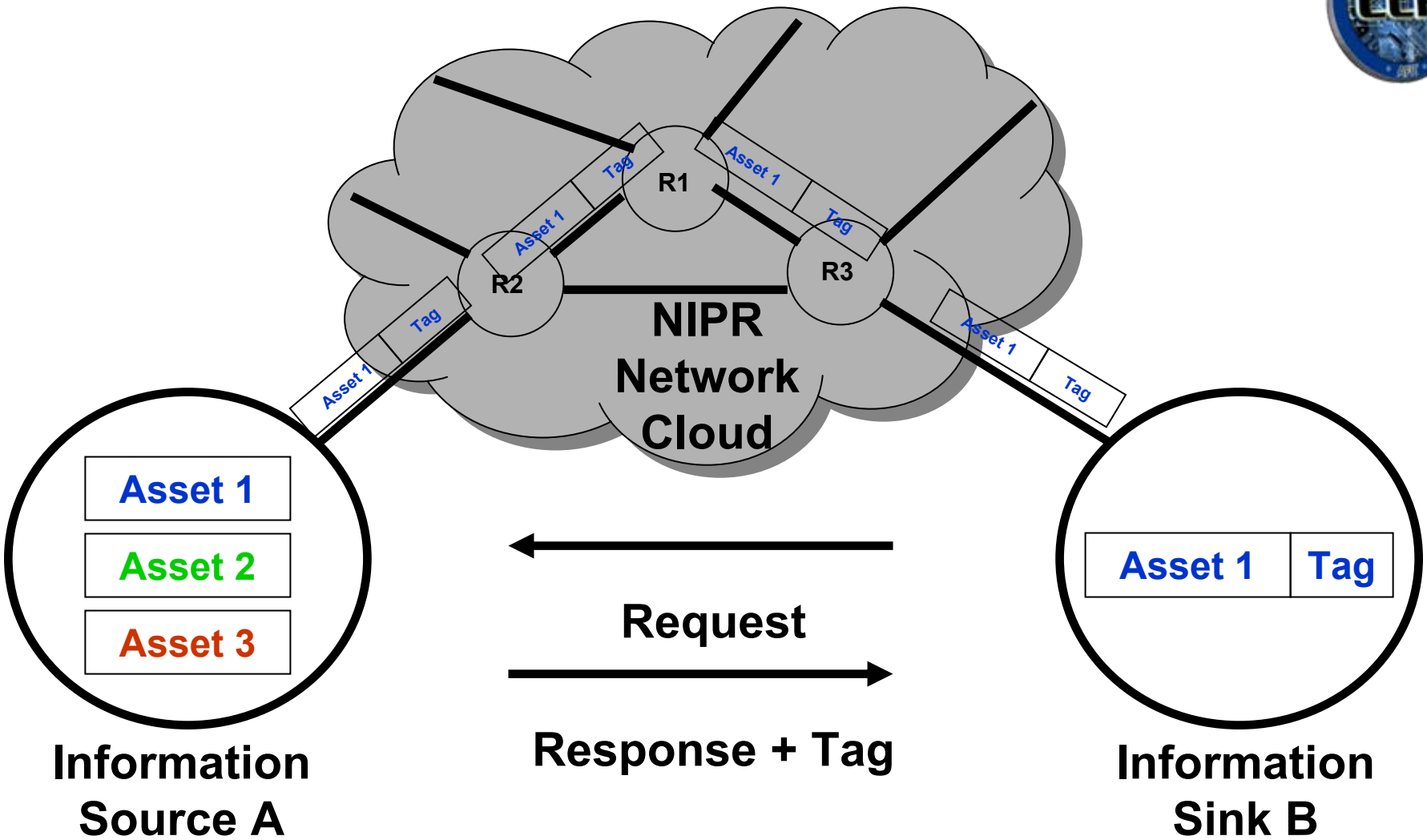
Tag	Owner	Producer	Age	Rated Criticality	Contains	SA_LABEL
7FD3BA30	AFIOC	33rd IOS	Daily	Very High	23A9D3D7, DD3100AC	TS-SCI/HCS
B723AA29	67th NWW	GREEN	10 June 2008	High	<NULL>	S/BELL
23A9D3D7	NASIC	SMAI	Daily	Very High	<NULL>	TS-SCI/TK
DD3100AC	NSA	GROUP 4	Weekly	High	<NULL>	TS-SCI/G

Note: Not all fields are shown for brevity

Tagging Information Assets

- Tags are “intelligently” inserted into the network data stream at the source:
  - One time for a given requestor
  - After a defined time interval has passed
  - When a change in the asset occurs
- Very low overhead impact
- Tag may be inserted in multiple ways (e.g., unused bits, IPV6 Flow Label, encoded into data)
- The tag itself does NOT contain any information about the information asset
- The tag is an encrypted using symmetric encryption
- The tag encryption changes daily using an automated process that is seeded monthly

Information Asset Source / Sink Architecture



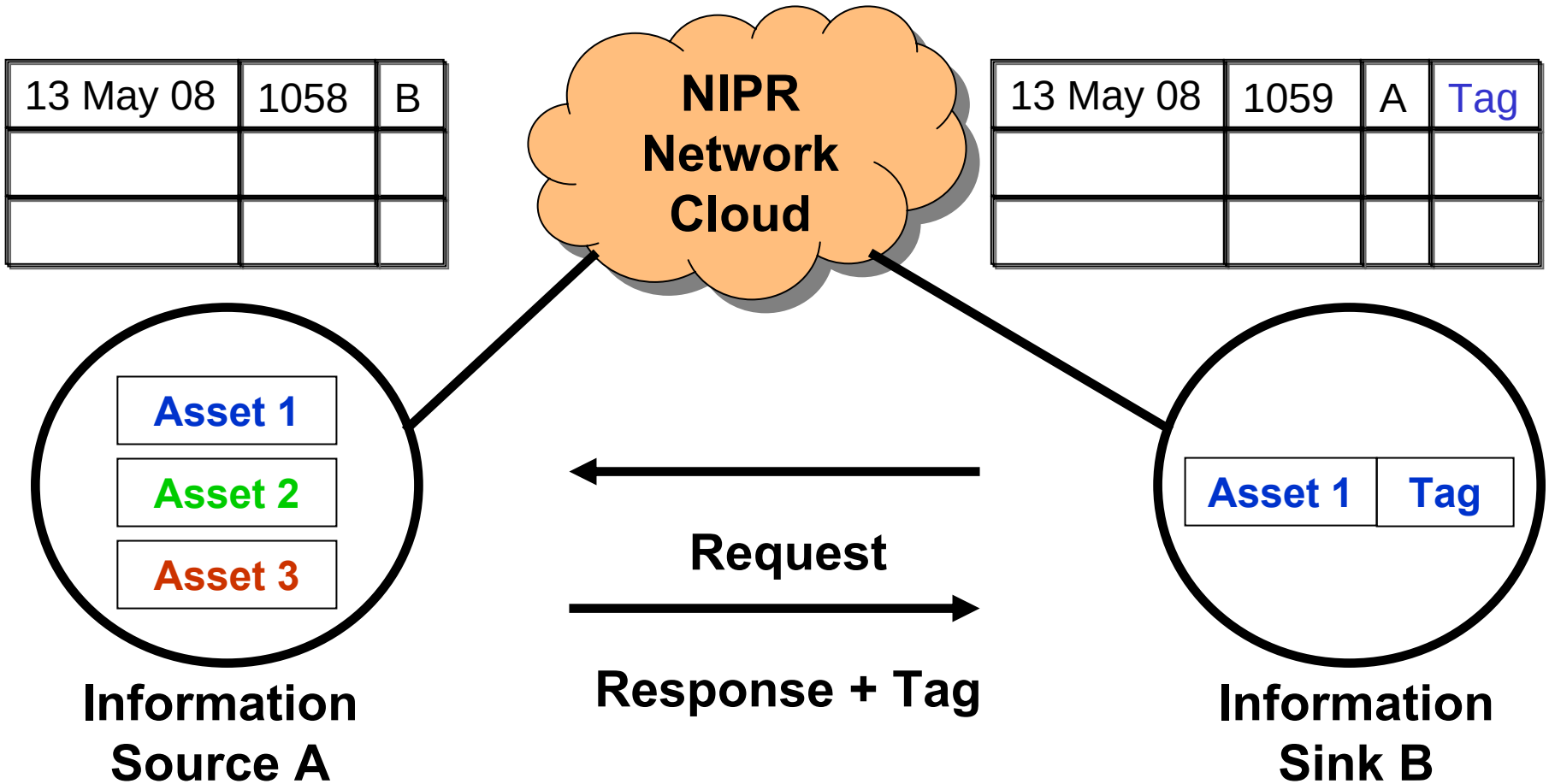
Source (Provider) Lightweight Database

- A lightweight database which keeps a record of all consumers who request an information asset
  - Collects summary statistics for each consumer including information asset tag, last access, frequency of access, amount of data transferred
- The source periodically transfers this information to a single local high side database (Tier III) which collects all requests made within the organization
- The information is periodically passed to Tier II, and then on to the Tier I systems
- Communication is passed through a one-way trusted guard

Sink (Consumer) Lightweight Database

- A lightweight database which keeps a record of all requests made to information sources
  - Collects summary statistics for each information asset received including the information asset tag, last access, frequency of access
- The consumer (or organizational representative) must explicitly link each requested information asset to the mission process(es) is supports and assign a “value” in terms of criticality of C/I/A
- The database is periodically transferred to a single local high side database (Tier III) which collects all information dependencies within the organization
- Similarly, this is transmitted securely up the chain

Source / Sink Lightweight Databases



Central Authority Process

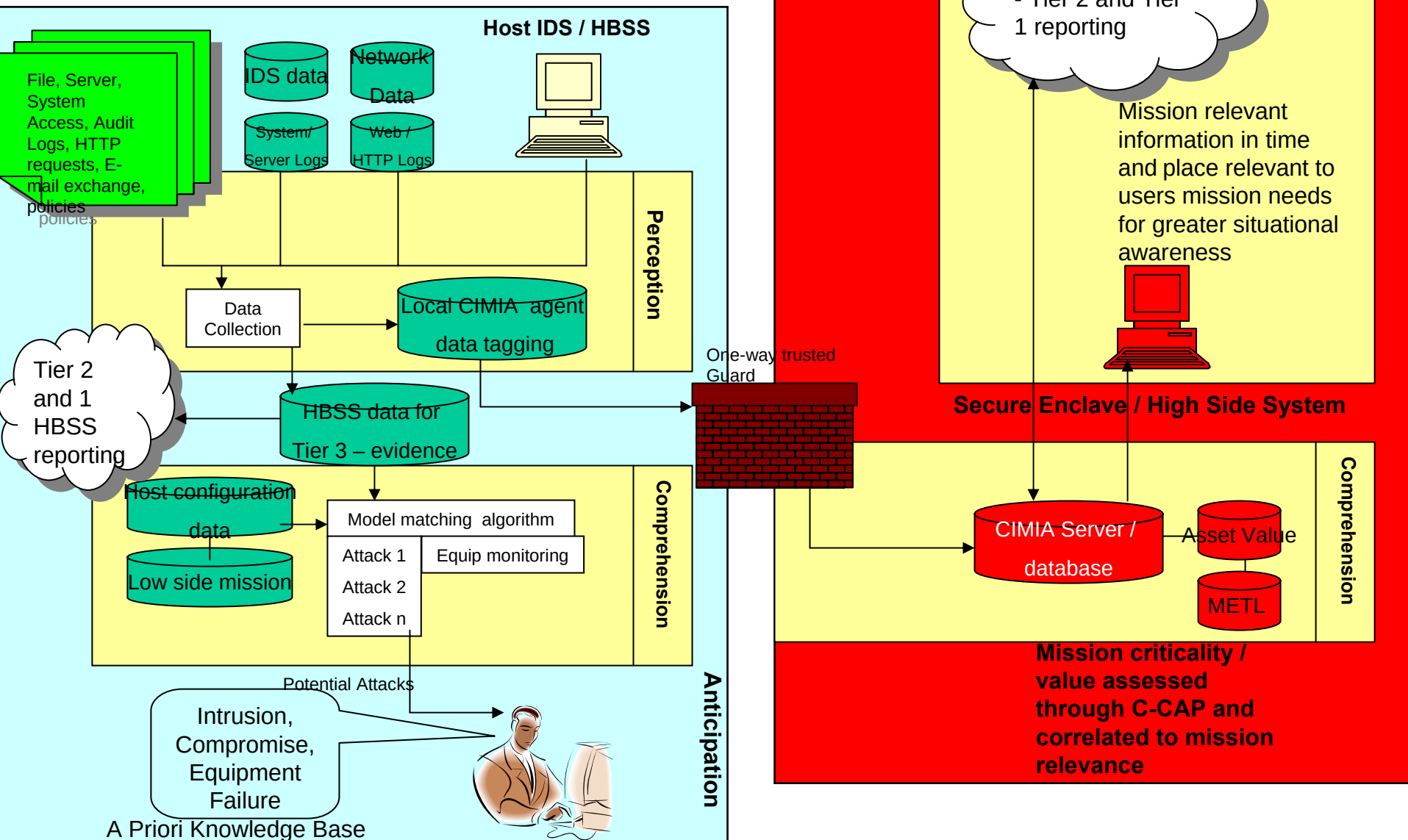
- Links information asset sources and sinks
- Determine all information dependencies
- Provides the capability to immediately notify downstream information consumers when an incident occurs
- Consuming organizations periodically download an encrypted message from the central authority
- Possible to calculate an aggregate enterprise-wide valuation for each information asset
- Consuming organizations are now accountable for identifying critical information resources
- Lesson learned can be shared

Host Based System Security (HBSS)

- An HIDS for workstations and servers
- Mandated to be installed on all DoD nodes
- Collects
  - Authentication information
  - Utilization of applications
  - File/System level access
- Does
  - Virus checking
  - Firewall monitoring
  - Malicious Traffic monitoring
  - Standard configuration enforcement
- Multi-tier level reporting
- Enables tag insertion and collection

(Gregory & Hensley 2007)

Proposed CIMIA System Architecture



Conclusions

- The research highlights the importance of documenting a formal risk assessment
- CIMIA can significantly improve the accuracy and timeliness of impact assessment
- Information asset identification is the first step in the CIMIA process
- Information asset tagging provides a mechanism to automate a portion of the task
- HBSS provides a vehicle for information tagging
- Prototype underway to show proof of concept

Questions

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