Clare Liu (刘波)

- 2003.7 — Graduated from HIT (Harbin Institute of Technology)。
- 2003.3-2007.2 — Worked for Applied Materials. Started as hardware engineer for etch equipment and then transferred to be Factory Automation and Software support engineer.
- 2007.2-2018.5 — Worked for Advanced Micro-Fabrication Equipment Co. Ltd. As a part of Factory Automation software team, implemented SECS/GEM, GEM300 and Interface A/EDA interfaces for AMEC equipment.
- 2008.5 — Joined Cimetrix as Smart Manufacturing Solution Consultant.

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Interface A / EDA Standards Overview and Adoption Status

Smarter Manufacturing Through Better Data: Applications and Benefits of SEMI Interface A / EDA Standards Workshop

January 10, 2020

Shanghai, China

Origin of the EDA standards
Industry motivation (circa 2001)

- Needed flexible approach for collecting and distributing high-density real-time equipment and process data
  - Fault detection algorithms were evolving from lot-level post-process application to within-process diagnosis and tool interdiction capabilities
  - Run-to-run control applications moving from lot level to wafer level
- Only alternatives were custom interfaces or vendor-specific data collection systems (i.e., expensive)
- EDA provided standard approach across tool types supporting a common client/host data collection system

Origin of the EDA standards
Performance expectations

- GEM-based data collection limitations
  - Maximum trace data frequency typically 1 Hz
  - Collection event aligned with substrate movement and recipe start/stop
  - OK for material tracking, OEE reports, and lot-level FDC and R2R control
  - GEM interface fixed or "locked down" to avoid tool performance problems
- Process engineers needed more/better data on their terms
  - At least 10 Hz frequency at recipe step boundaries
  - 100 Hz frequency for critical, rapidly changing parameters
  - Precise data "framing" for advanced predictive algorithms
  - Dynamic sampling in response to changing process conditions
  - Define new data collection plans (within limits) without additional sign-off

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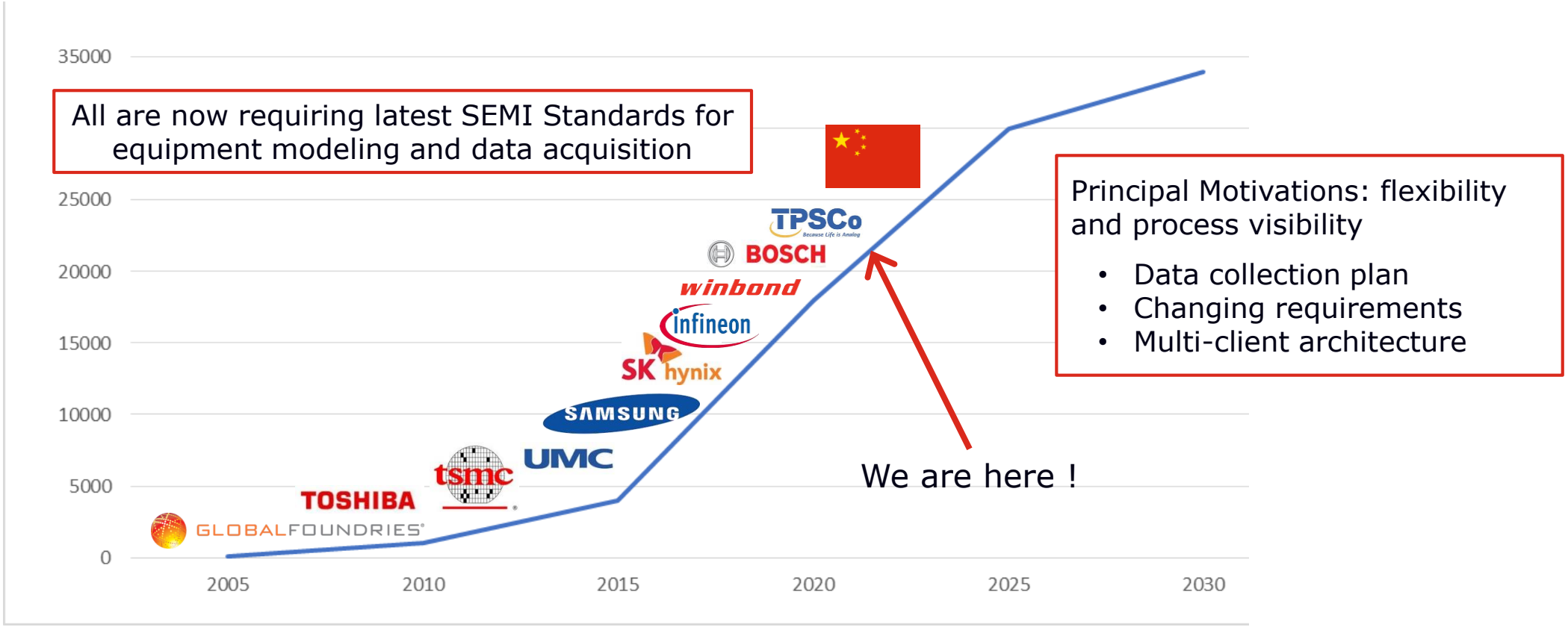
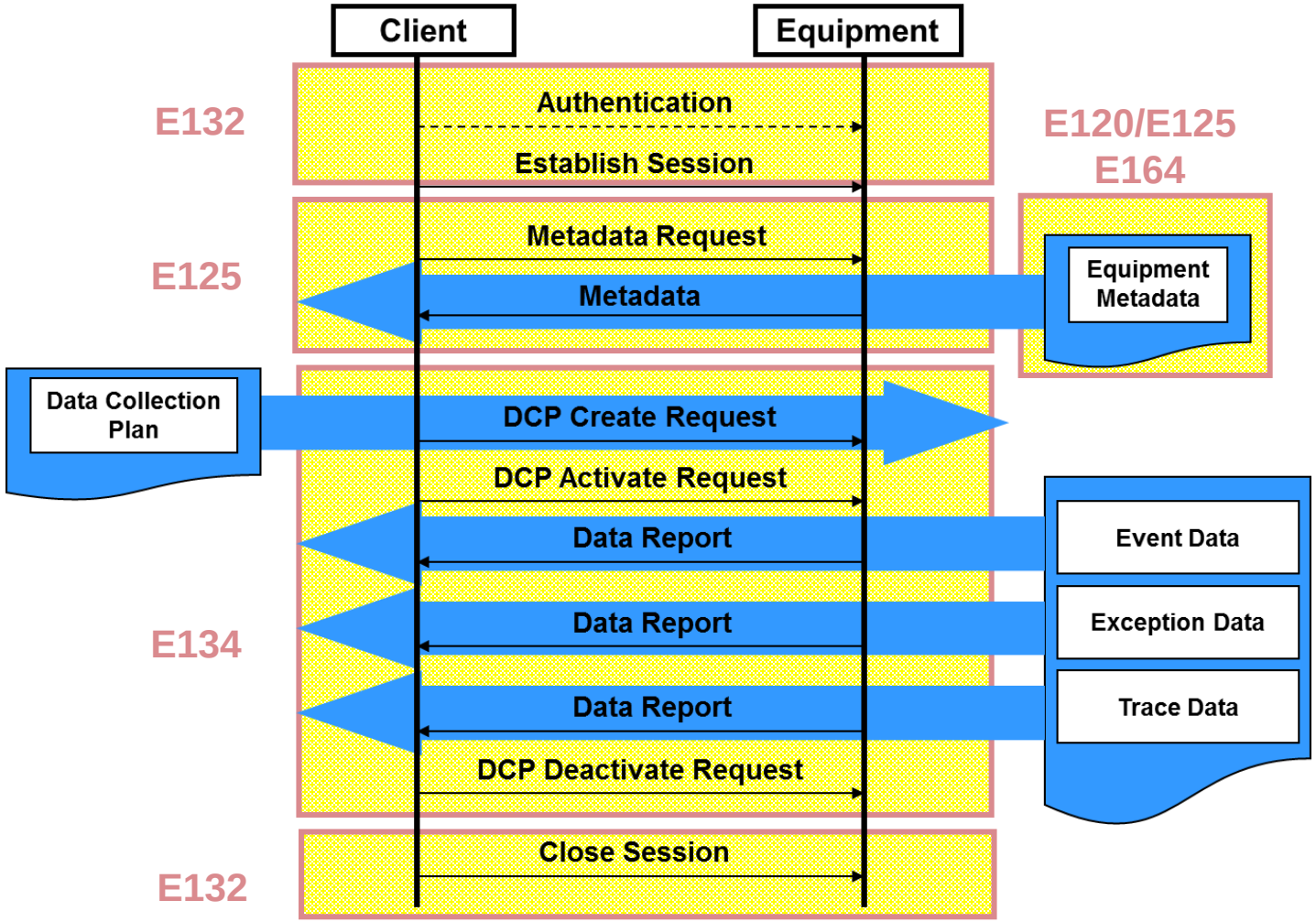
EDA adoption status

Cumulative # of production tools installed



EDA Operational Sequence

How the individual standards fit together



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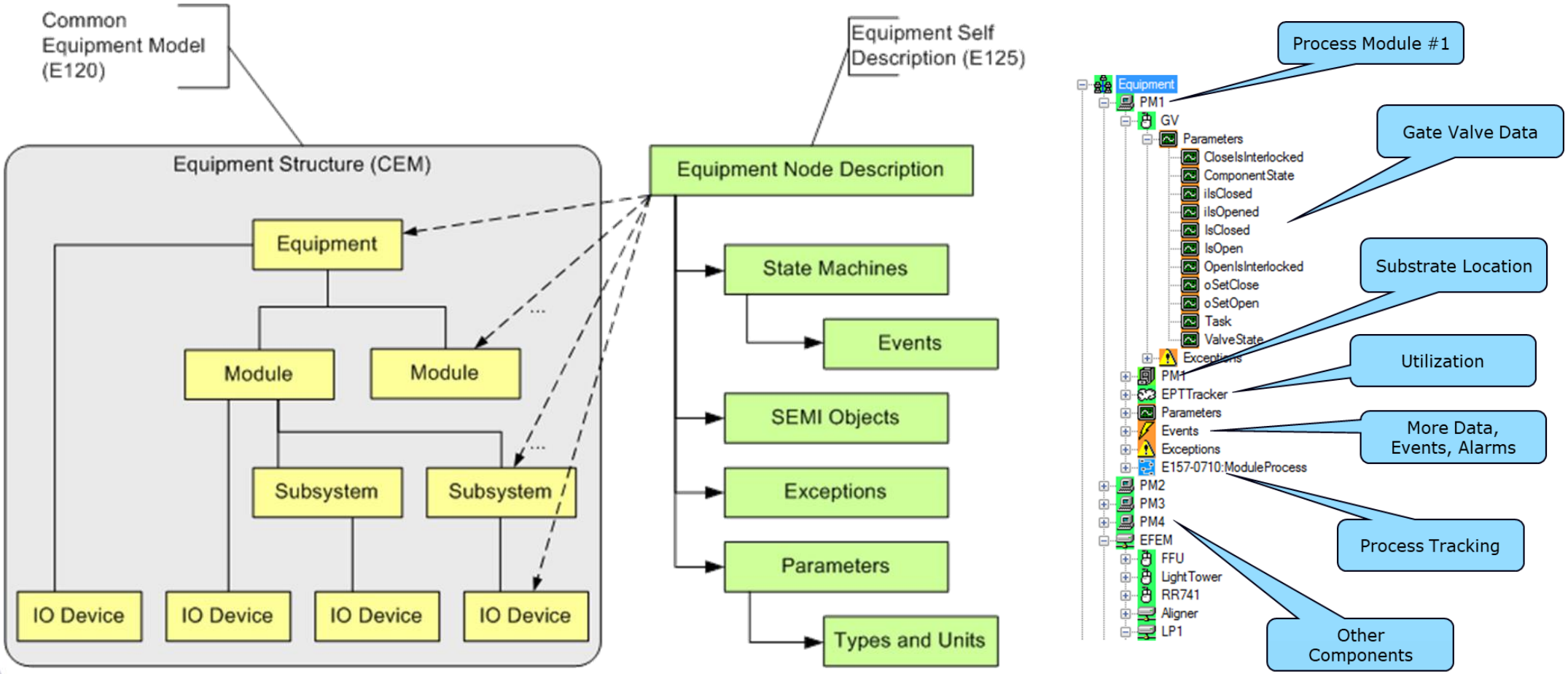
SEMI EDA equipment metadata model

Structure, nodes, self-description services



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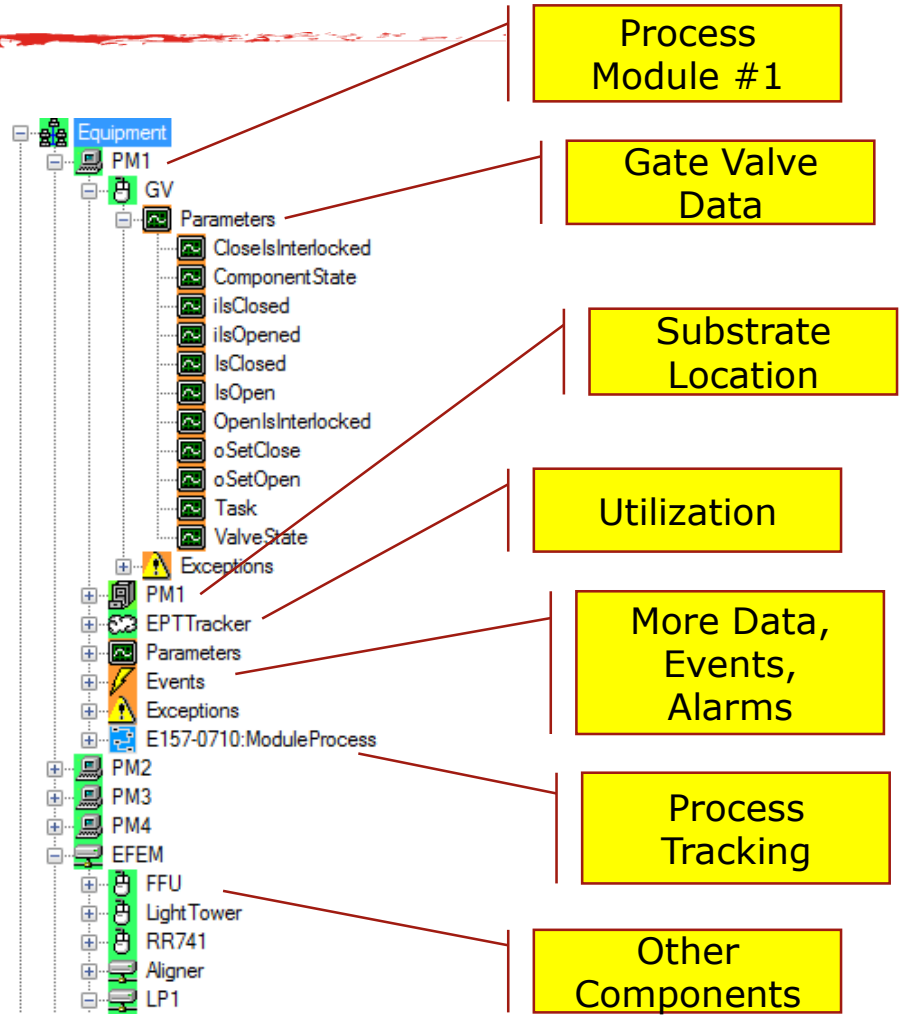
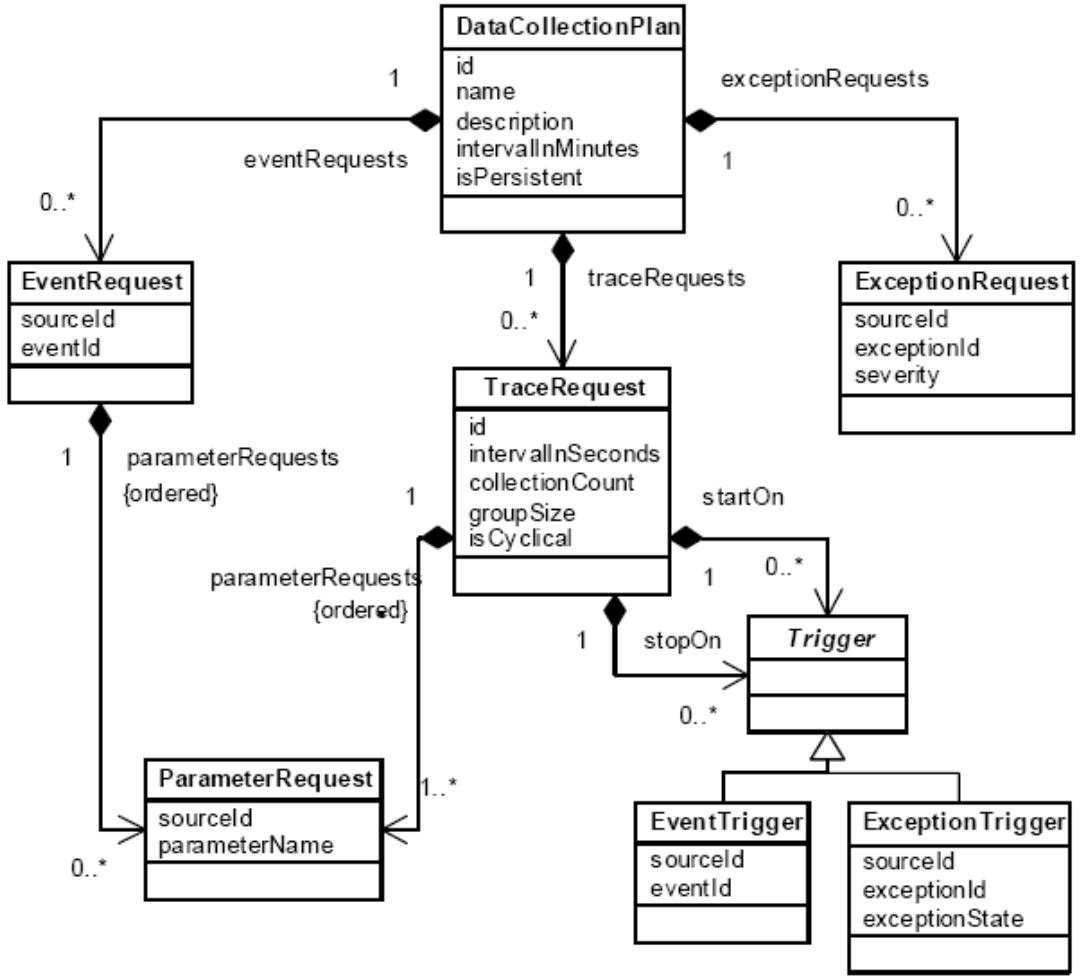
Equipment Metadata Model Benefits

- Standards for all equipment models
- Model structure exactly reflects tool hardware organization
- Complete description of all potentially useful information in the tool
- Always accurate, always available – no additional documentation required
- Common point of reference among tool, process, and factory stakeholders
- Source of unambiguous identifiers/tags for database [auto] configuration
- Enables "plug and play" applications



SEMI EDA Data Collection Plan (DCP)

Structure for expressing application needs



From SEMI E134 – Data Collection Management

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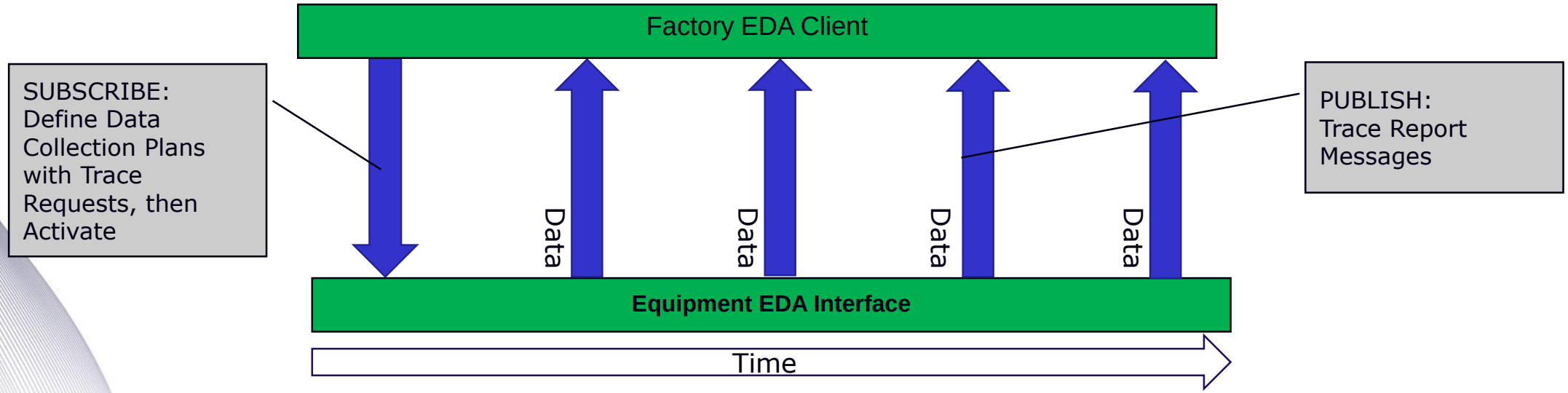
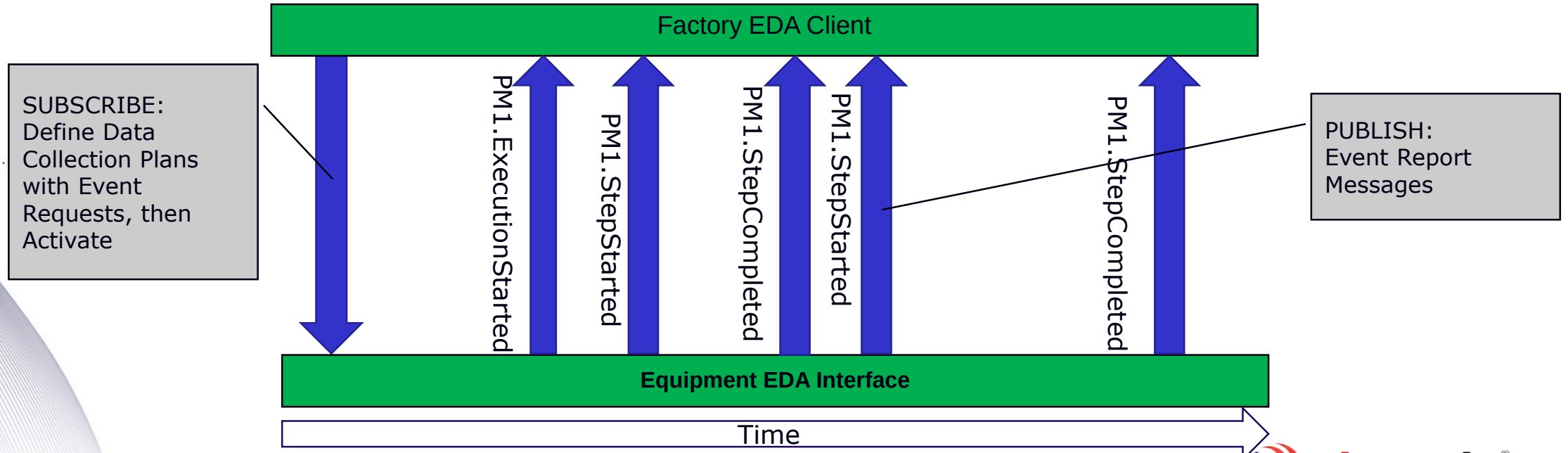
Trace Data Collection

- Poll equipment data
- EDA client subscribes only to the data it wants
- Conditional triggers use events to determine when data collection starts/stops



Event Data Collection

- Track when important activities occur on the equipment
- Collect related data
- EDA Client subscribes only to the events and data it wants



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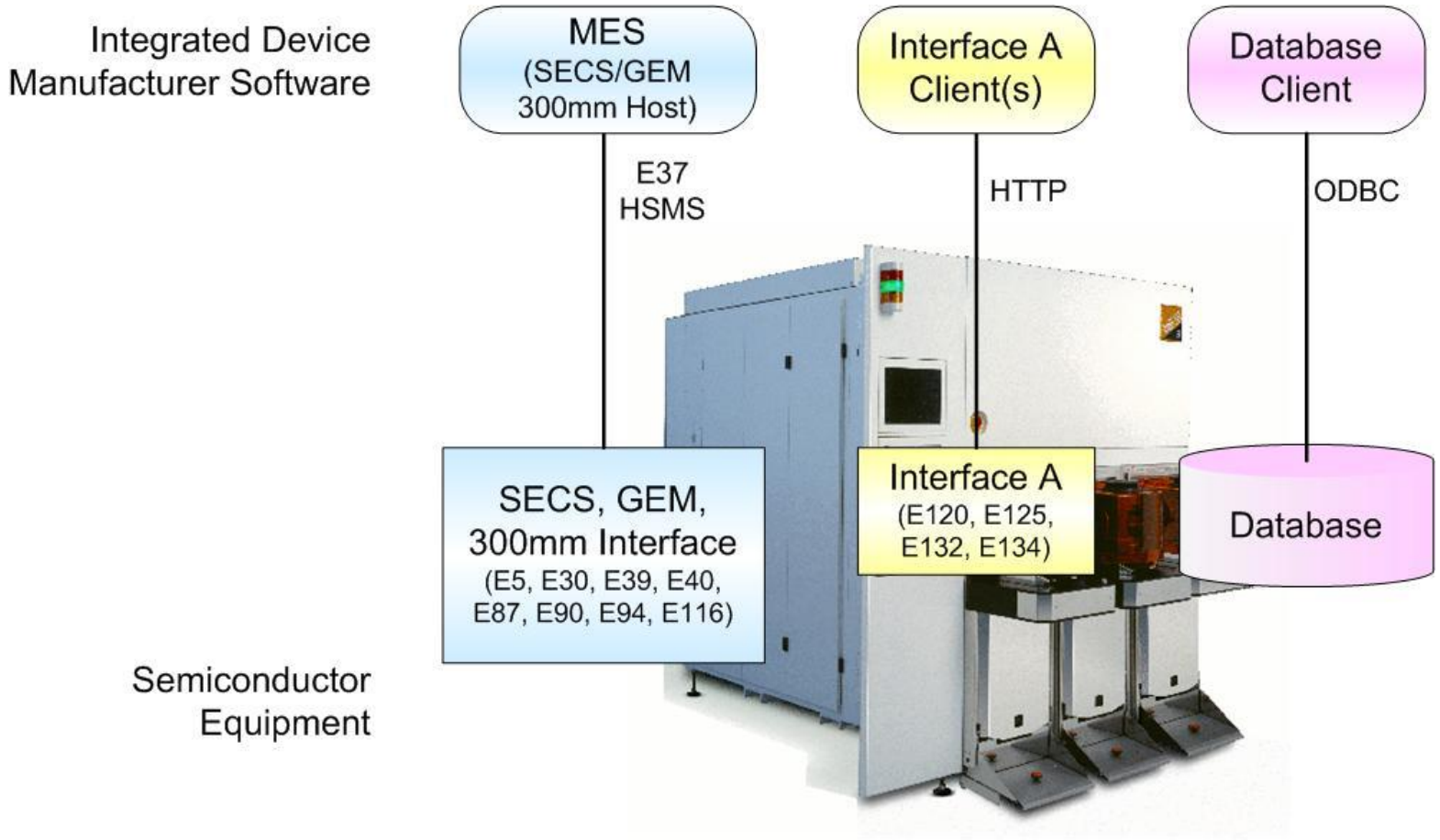
What is EDA, versus GEM?



Equipment Communication Standards Comparison

GEM	EDA
TCP/IP Binary Protocol	HTTP, SOAP/XML, Web Services
Control and Monitor	Monitor only
Requires Documentation	Self-Describing Metadata
Single Point of Communication*	Multiple, Independent Clients
Mature, Widespread Adoption	Cutting Edge, Freeze II Technology
Publish/Subscribe Event, Alarm Notification, With Data	Publish/Subscribe Event, Alarm Notification, With Data
Data Polling (Traces)	Data Polling (Traces), With optional Triggers to Start/Pause Collection

* Cimetrix offers for multi-hosting no extra charge.

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EDA Freeze Version Review

www.cimetrix.com

Freeze versions and SEMI E164
Purpose, scope, and implications

- Freeze versions
  - Ensure the interoperability of the underlying component standards (E125, E125.1, E132, E132.1, E134, E134.1)
  - Deal with service message formats (WSDLs) and protocols (HTTP/SOAP)
- SEMI E164 – EDA Common Metadata Standard
  - Ensures the consistency and completeness of equipment metadata models across the industry (E120, E125)
  - Deals with model structure, content, and naming conventions
- Implications
  - Freeze versions and E164 are independent, orthogonal requirements
  - An equipment model for ANY freeze version could be E164-compliant
- In practice…
  - Most device makers now require E164 with Freeze II; ALL will at Freeze III

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Freeze Version Overview

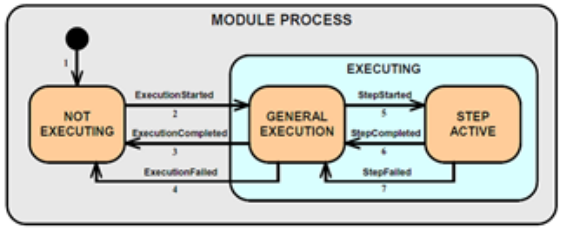
- Specific set of the SEMI standards
- Freeze versions required for client and equipment compatibility
  - Without freeze versions, EDA could not work
  - Nature of web service technology
- Freeze I
  - November 2005
- Freeze II
  - July 2010
- Freeze III
  - Under development

EDA Standards "Beyond" Freeze II

- Standards approved after 2010
- E164-0313 – Common Metadata
  - Standardizes the structure and content of equipment metadata for 300mm equipment
- E157-0611 – Recipe Execution Tracking
  - Supports process data collection during recipe execution

What does E164 specify?
Structure and content of equipment metadata

- E120/E125 Common Equipment Model usage/content
  - Nodes and parameters must have meaningful descriptions
  - Equipment element attributes for all E120 nodes must have meaningful values
  - All definitions (exceptions, SMs, parameter types, units, SEMI object types) must be referenced
  - Strict event name enforcement
- State Machines
  - Strict State Machine definitions
  - Requires E157 State Machines for all process modules
  - Requires E90 State Machines for all substrate locations
  - Requires all Parameters, Events and Exceptions defined in Freeze II standards to be present
  - State and transition names must match GEM300 standards



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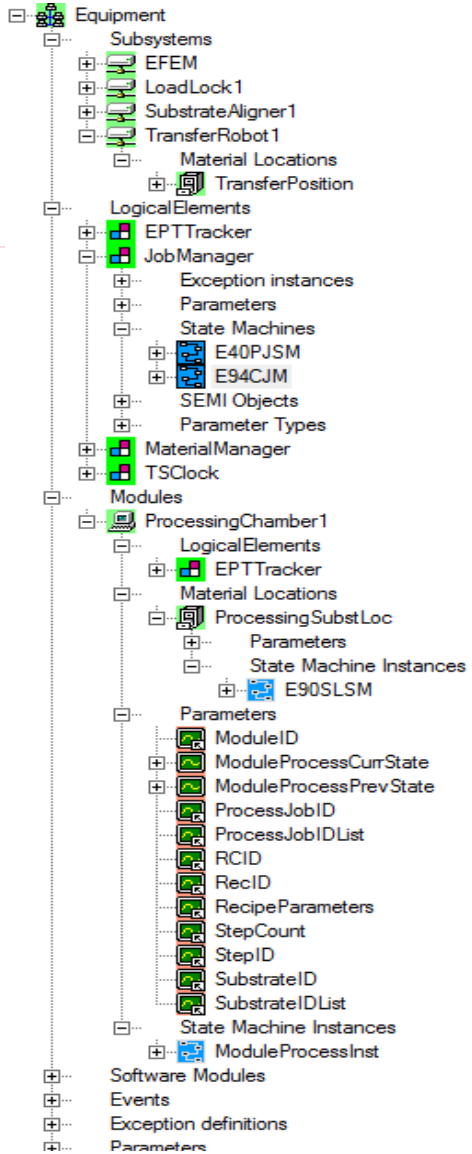
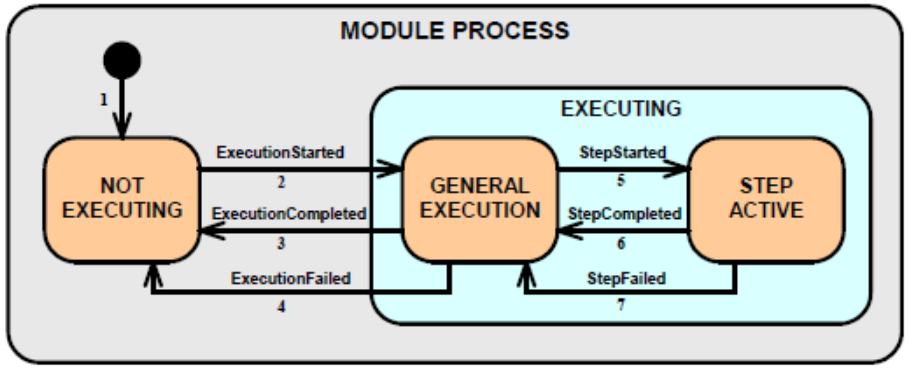
Why is E164 so important?

- Common metadata results in…
  - Consistent implementations of GEM300
  - Commonality across equipment types
  - Automation of many data collection processes
  - Less work to interpret collected data
  - Enables true "plug and play" applications
  - Major increases in engineering efficiency



Why is E157 so important?

- Standardized state model
  - Same event structure from all suppliers
  - Consistent context data from all suppliers
    - Job ID, Module ID, Step ID, Step Count
- Processing start/end
- Recipe Step start/end
  - Ideal for trace data collection
  - Reduces quantity of data



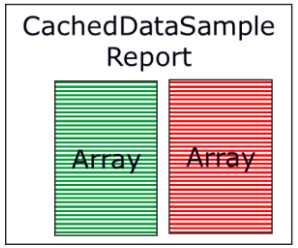
- Source: GLOBALFOUNDRIES "SEMI E157 – Recipe Execution Tracking" SEMI Standards / ISMI EDA Interface Workshop, 13 July 2011, SEMI E157 Update – v0.2.pdf

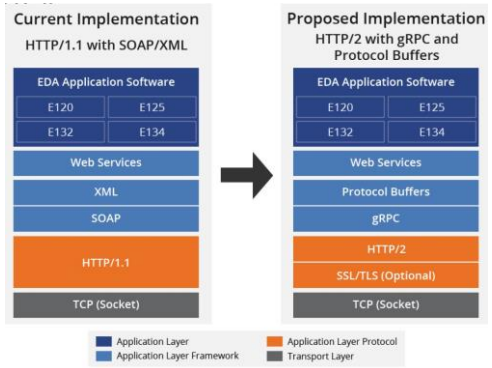
Access to EDA Standards

- Schema, WSDL files available for free
  - SEMI website
  - Available as a set by freeze version
  - ZIP file
- Freeze versions
  - Originally defined by ISMI
  - Added to E132.1 in 2015

EDA Freeze III
Content and timing

- Content
  - Small changes to E128, E132, E138
  - Medium changes to E125, E164
  - E134 (Data Collection Management)
    - Cached data sampling for high-frequency/density data
  - Big change to underlying protocols for increased efficiency
    - HTTP/2 with ProtocolBuffer technology
      - gRPC can be used (open source from Google)
    - Binary message transfer
- Timing
  - Some ballots being prepared now and ready for vote
  - Likely approval: 1-2 years
  - Forecast adoption/implementation: 2-3 years





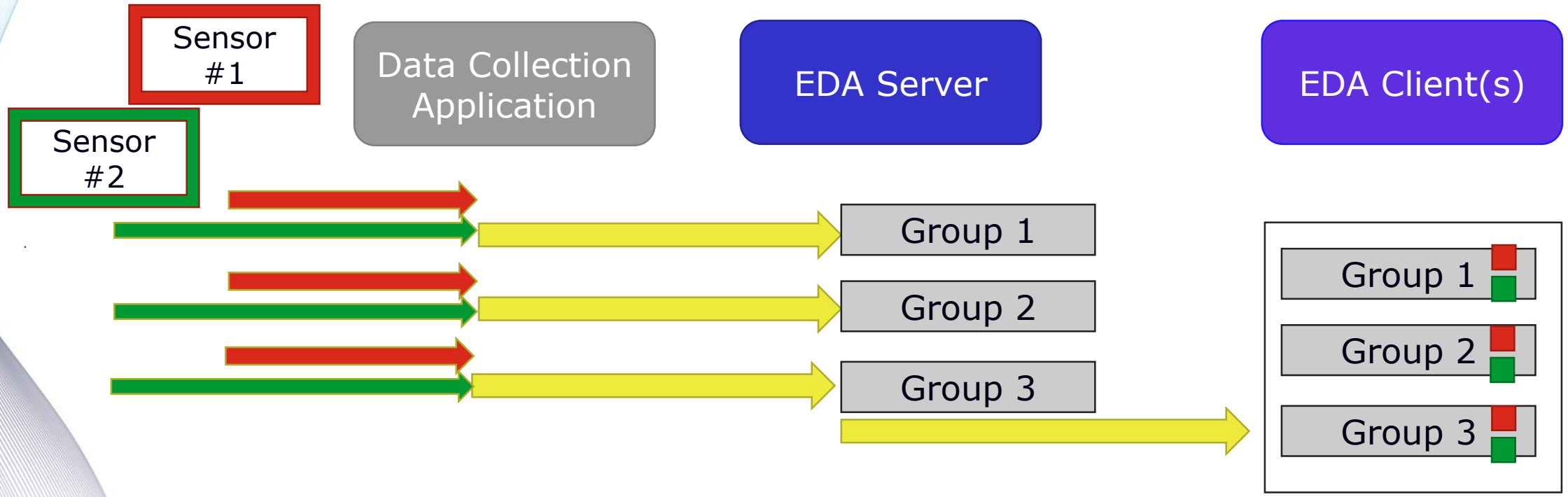
High Frequency Demand

Example: real-time arc detection sensors

- How can you report data collected at higher rates like 1 kHz or 10 kHz?
- A trick available today:
  - Publish an Event at a set frequency
  - Sample the data at a fixed rate and publish the data as an array
  - By publishing the data as an array, you can report data collected at very high frequencies because the data is packaged efficiently, and because you are not sending frequent trace reports
- Limitations with this trick:
  - Requires special programming in the equipment's EDA implementation
  - Client must know how to interpret the data
  - There is no way for the EDA client to choose the reporting frequency
  - There is no way for the EDA client to choose the data sampling frequency

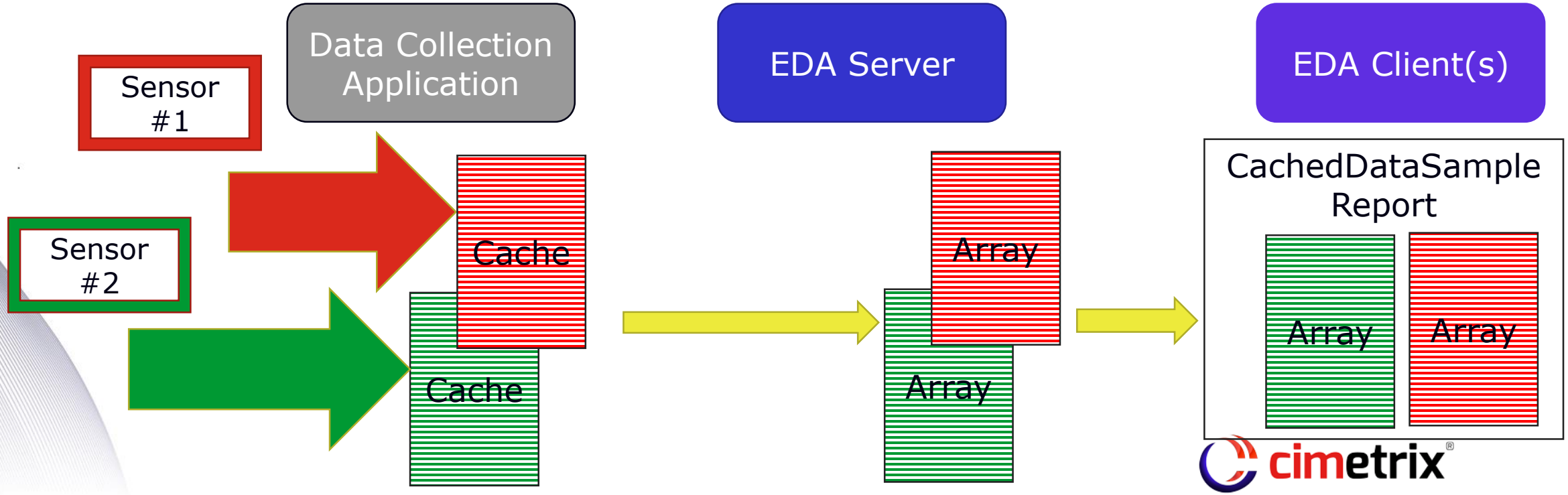
Current Trace Implementation
Freeze II

- Data is collected, reported, one sample at a time
- Even with trace report grouping, this is still true



CachedDataSample Implementation
Freeze III (proposed modifications to E134)

- Data is collected and cached at a low level, either by the sensor or a special data collection application
- Data is kept as an array in the EDA server and sent to the client as an array. Handshake frequency and bandwidth are dramatically reduced



联系我们

- Cimetrix 官网： www.cimetrix.com

Cimetrix 微信公众号

SEMI 中国 EDA 讨论群

Thank you

- 谢谢
- 謝謝
- 감사합니다
- Merci
- Danke
- ありがとうございます
- Gracias

EDA Standards Detailed Information

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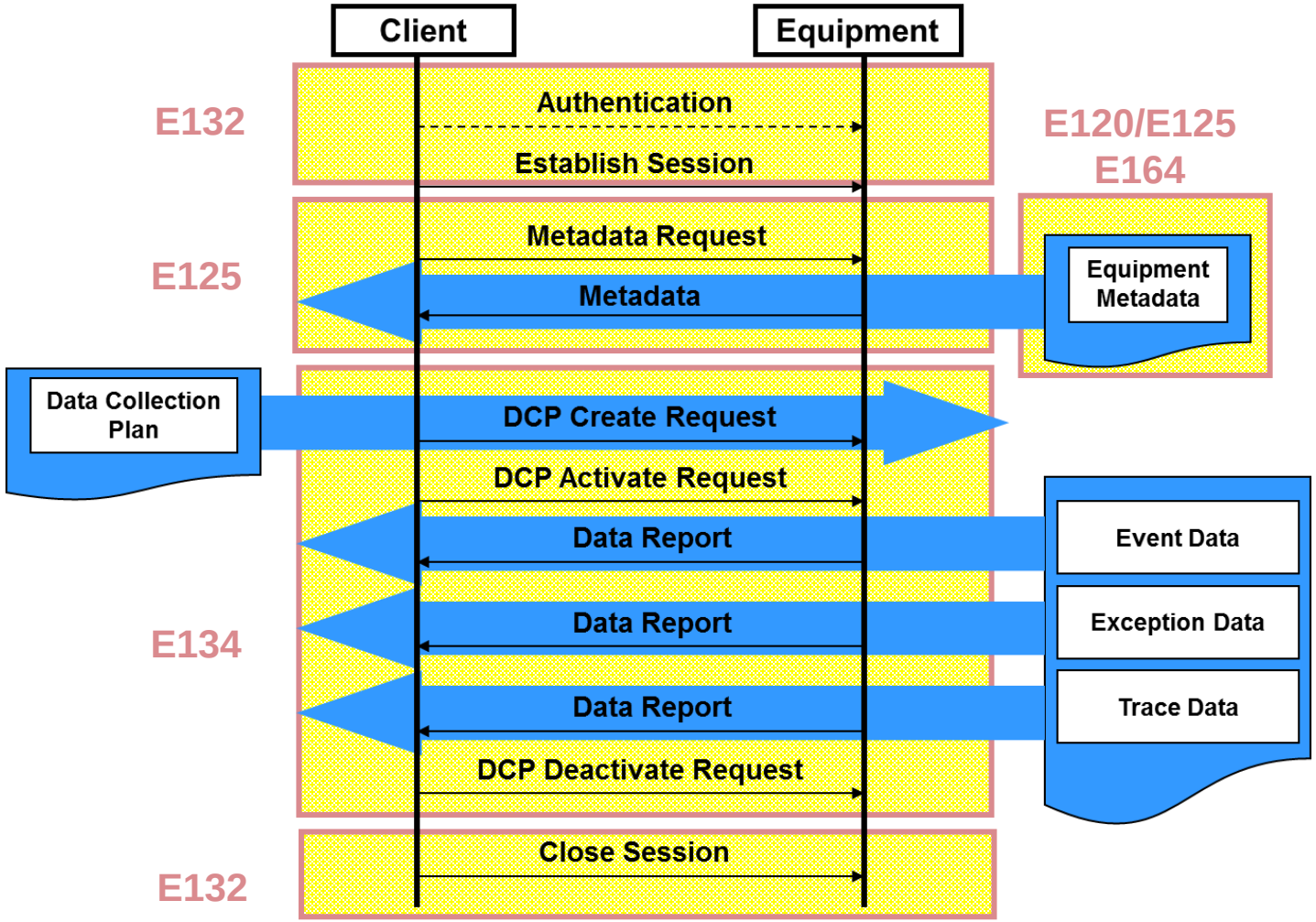
EDA Operational Sequence



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1. Establish Communication

E132 Specification for Client Authentication & Authorization

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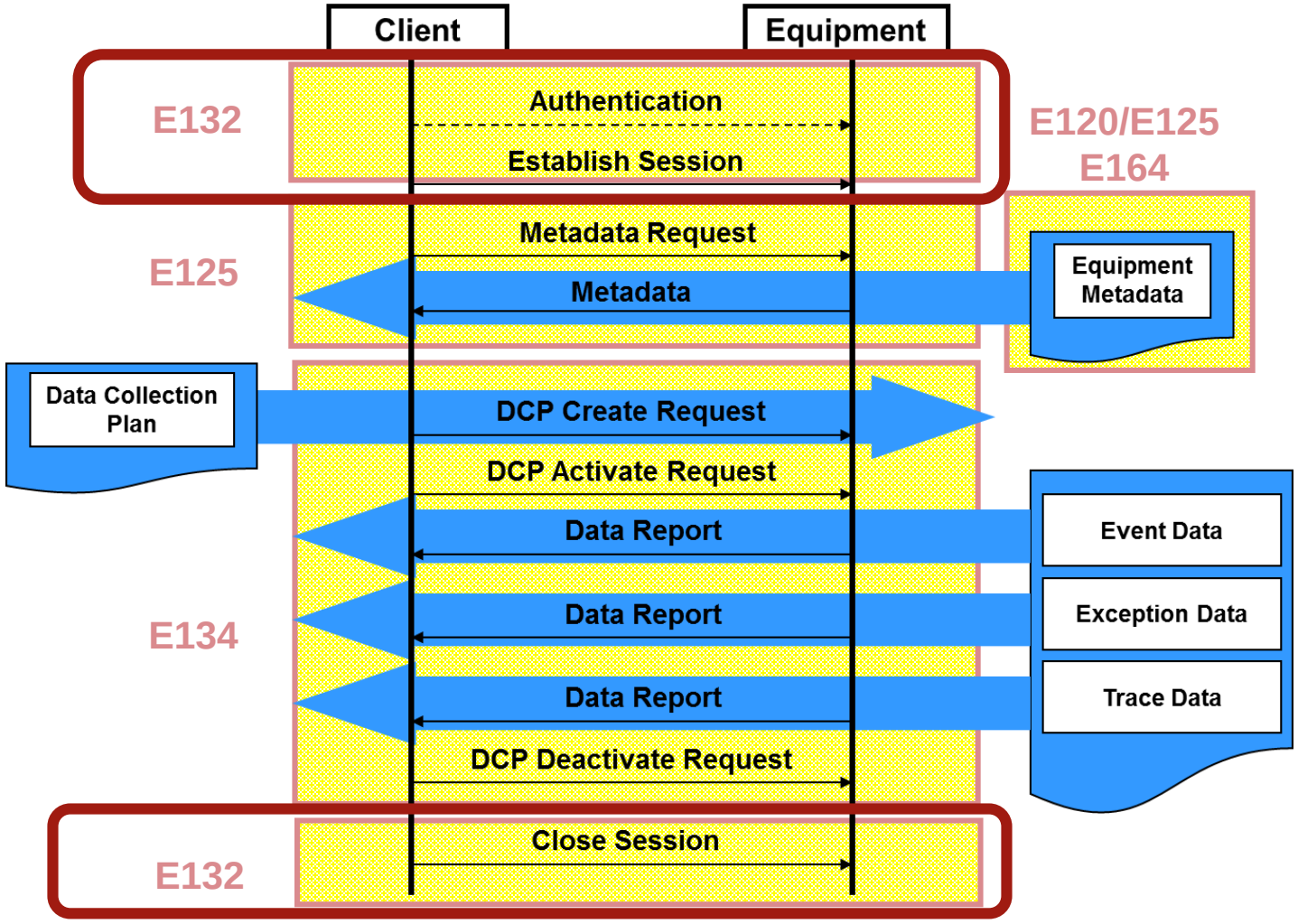
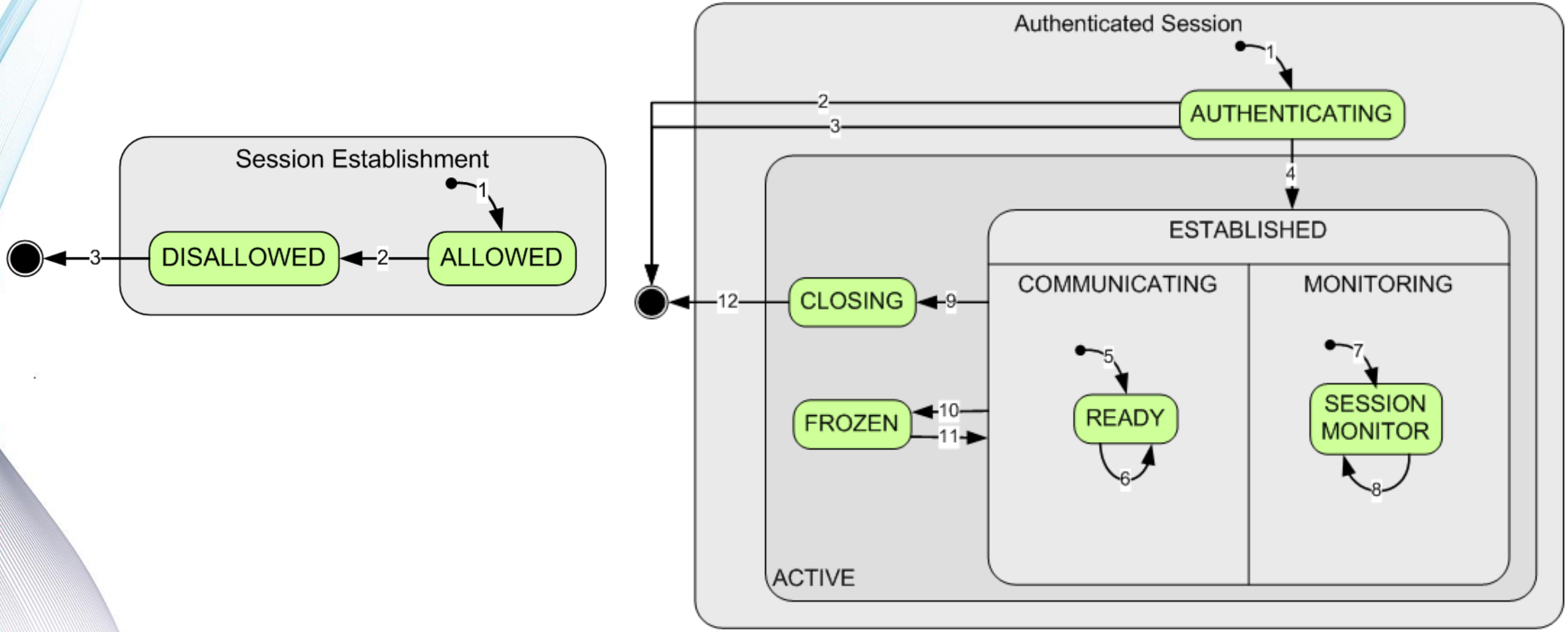
E132 Context



Session State Models



E132 – Equipment Services

- EstablishSession
  - Request to establish a new authenticated session and to set the client endpoint, the consumer for all notifications from the equipment.
  - EnhancedEstablishSession, 0710 version
- PersistSession
  - Request the Equipment to maintain the session, even after shutting down the Equipment.
  - In versions 0710 and later, this operation does not exist because all sessions are persisted.
- SessionPing
  - A check to see if the Equipment is still active.
- CloseSession
  - Request to terminate the session.

E132 – Client Services

- SessionPing
  - Used by the equipment to check if the client is still active.
- SessionFrozen
  - Notification to the client that the session will be frozen.
- SessionClosed
  - Used by the equipment to close an active session.

E132 – Equipment Admin Services

- GetDefinedPrivileges
  - Request the list of all defined privileges.
- GetACL
  - Request the list of all defined Access Control List entries
- AddACLEntry
  - Add a new ACL entry
- DeleteACLEntry
  - Delete an existing ACL entry
- GetActiveSessions
  - Request the list of information on all active sessions
- SetMaxSessions
  - Sets the maximum number of active sessions
- GetMaxSessions
  - Requests the maximum number of active sessions

0710 New E132 Interface

- InterfaceDiscovery
- GetInterfaces
  - Returns list and discription of web interfaces, including the URLs

2. Equipment Modeling

E120 Specification for the Common Equipment Model

E125 Specification for Equipment Self Description

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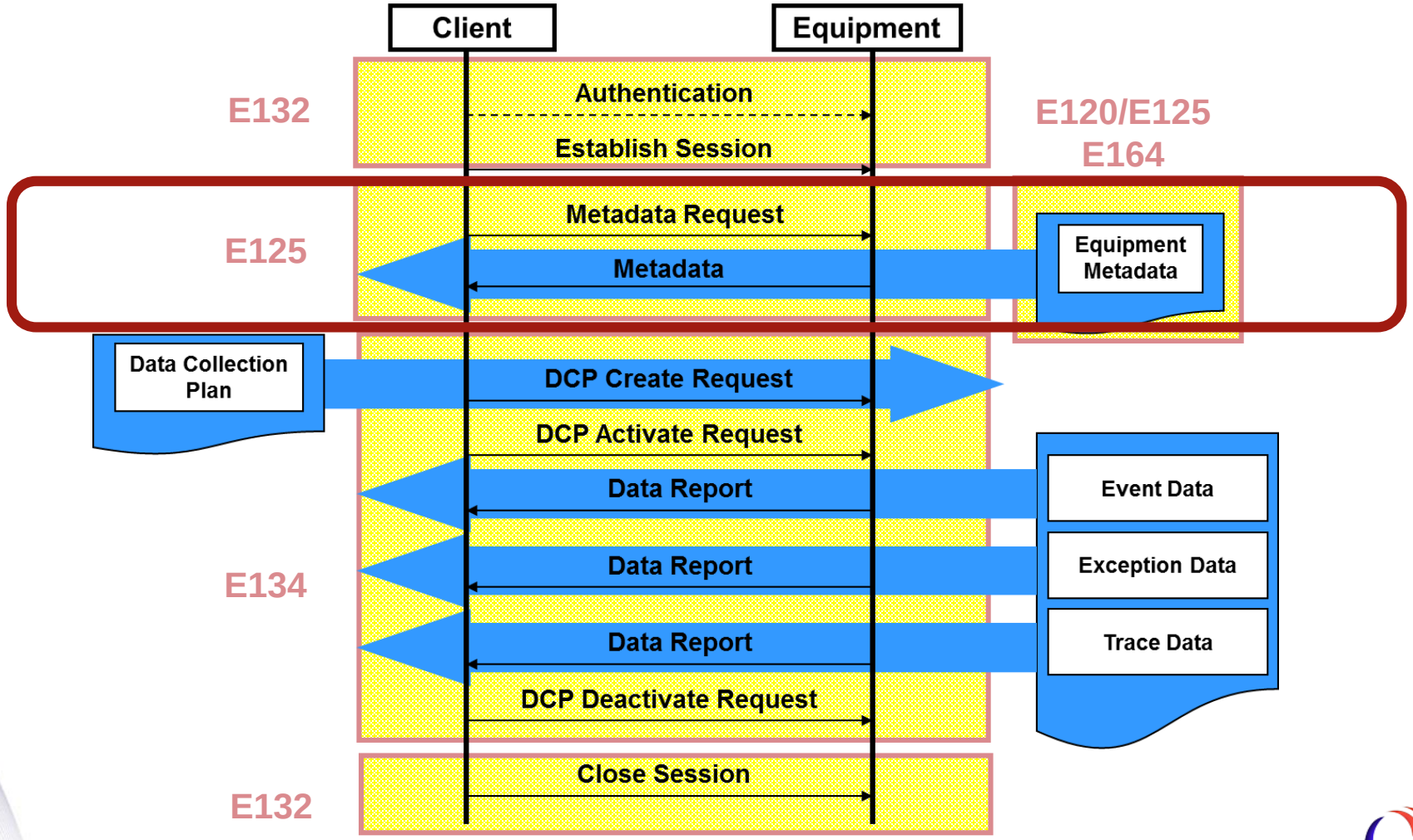
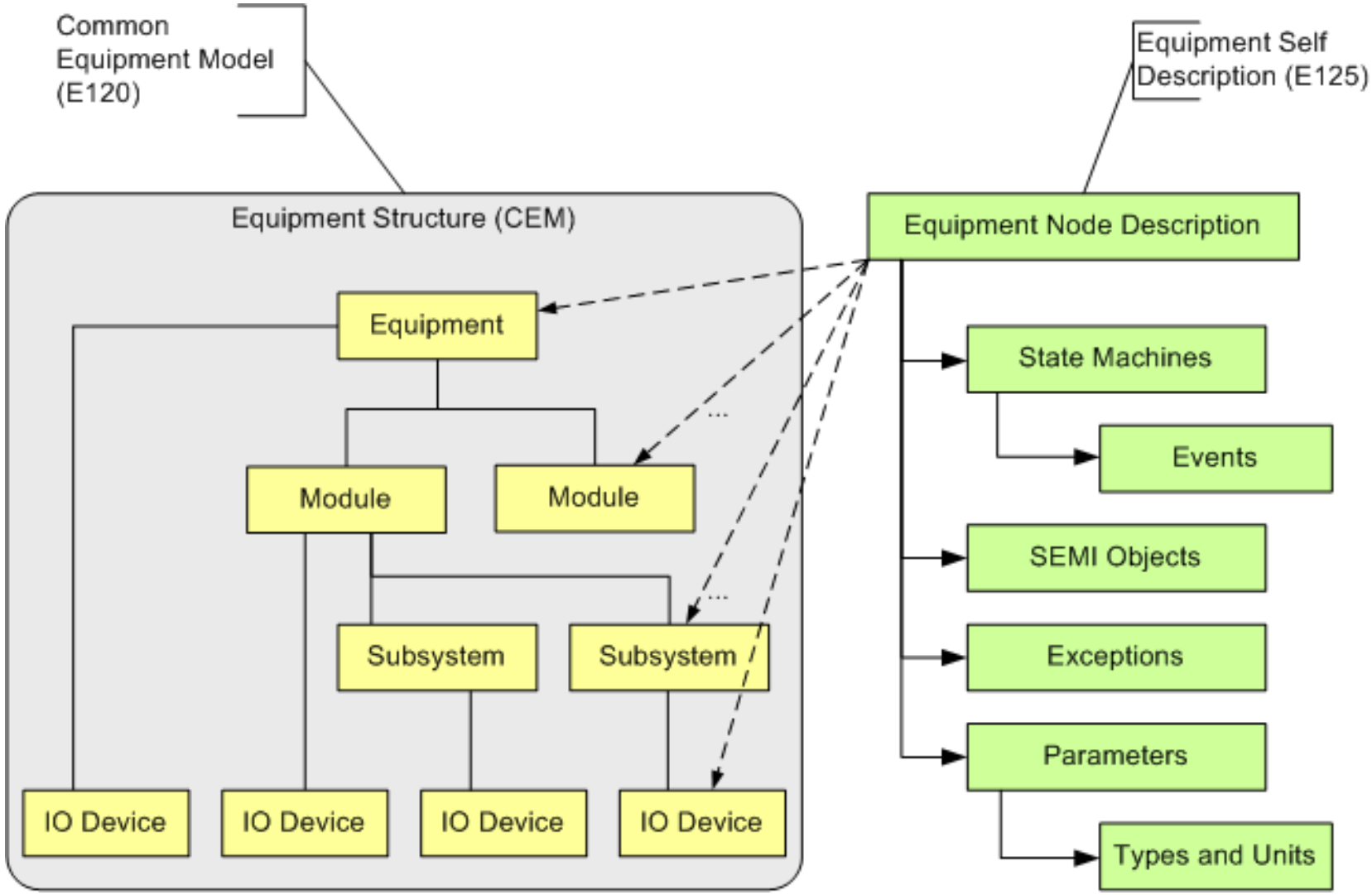
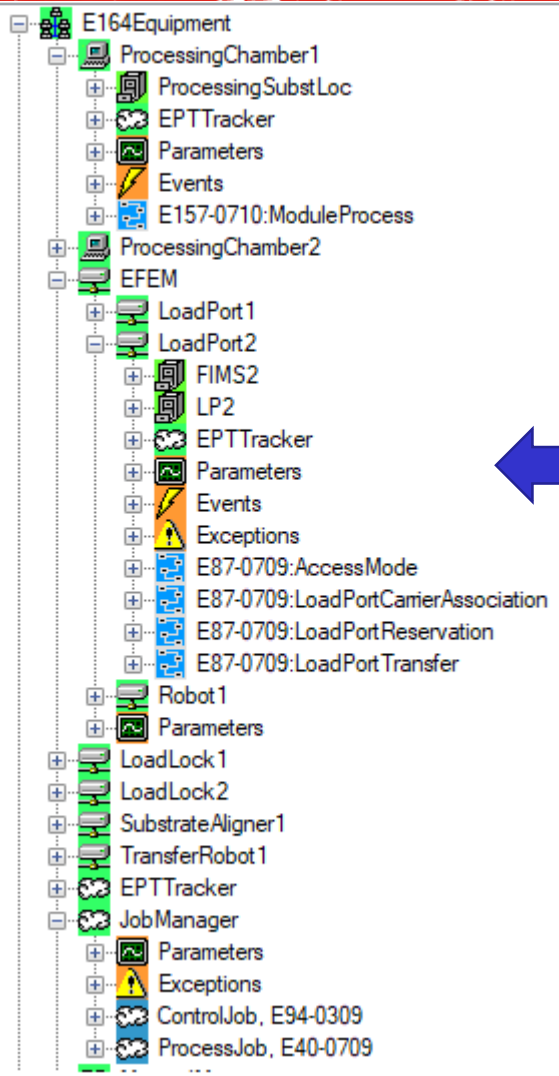
E120, E125 Context




Common
Equipment Model
(E120)
Equipment Self
Description (E125)
Equipment Structure (CEM)
Equipment Node Description
Equipment
Module
Module
Subsystem
Subsystem
IO Device
IO Device
IO Device
IO Device
State Machines
Events
SEMI Objects
Exceptions
Parameters
Types and Units

EDA Model (Hierarchy)

Factory
EDA Client



E125 – Equipment Services

- GetEquipmentStructure
  - Retrieves all equipment node metadata in a hierarchal structure.
- GetEquipmentNodeDescription
  - Retrieves individual equipment node metadata including:
    - Parameters associated with this node
    - E39 objects/SEMIObjTypes that are associated with this node
    - State machine instances that are associated by this node

E125 – Equipment Services

- GetUnits
  - Retrieves unit metadata
- GetTypeDefinitions
  - Retrieves parameter type metadata
- GetSemiObjTypes
  - Retrieves E39 object type metadata
- GetExceptions
  - Retrieves exception metadata
- GetStateMachines
  - Retrieves state machine metadata

E125 – Equipment Services

- GetLatestRevision
  - Retrieves the last data and time at which the equipment metadata was revised
- NotifyOnRevisions
  - Request that the equipment notify the client when changes to the metadata are made

E125 Client Services

- MetadataRevised
  - Notifies the client that the equipment metadata has been changed.

3. Data Collection

E134 Specification for Data Collection Management

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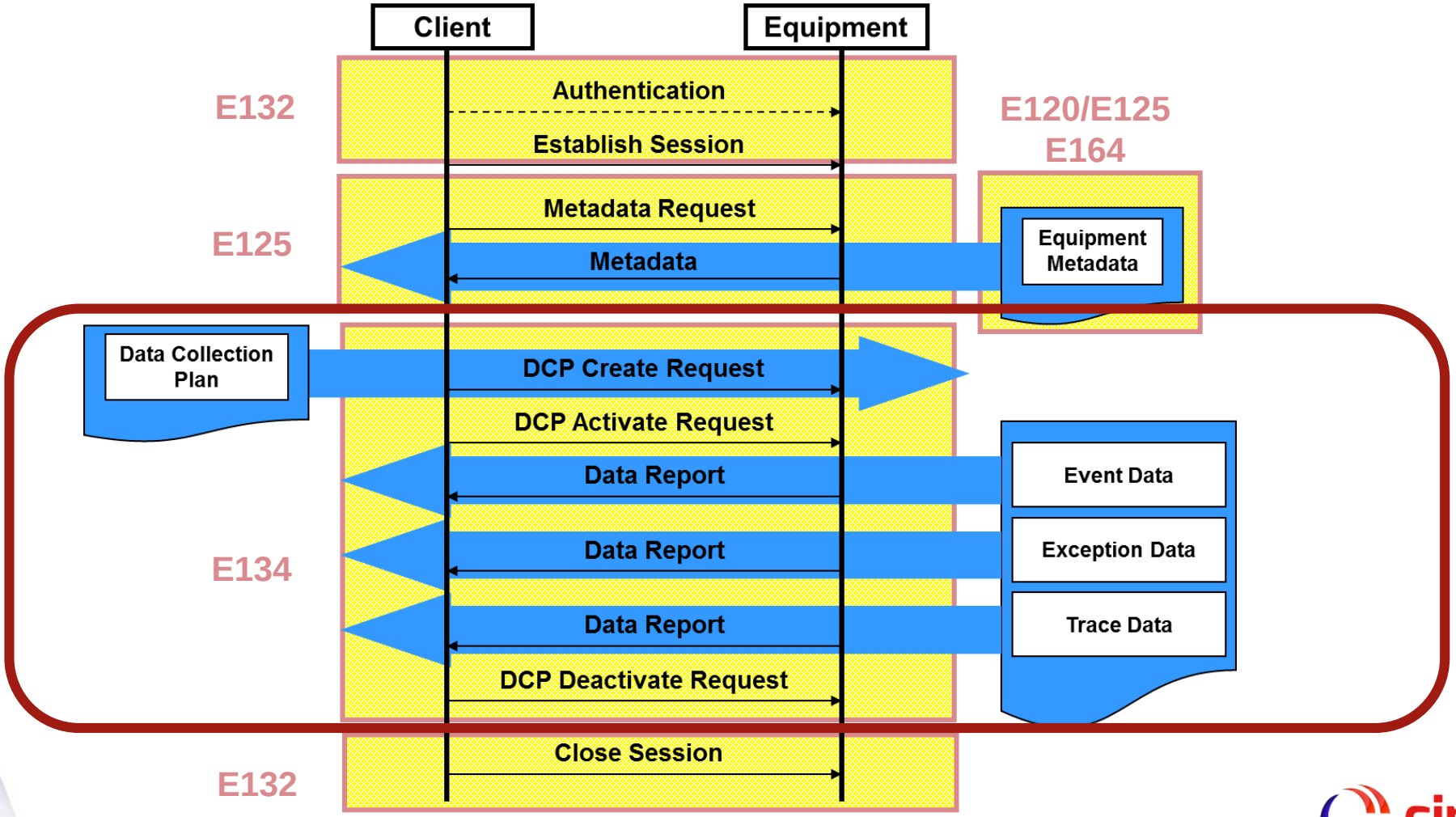
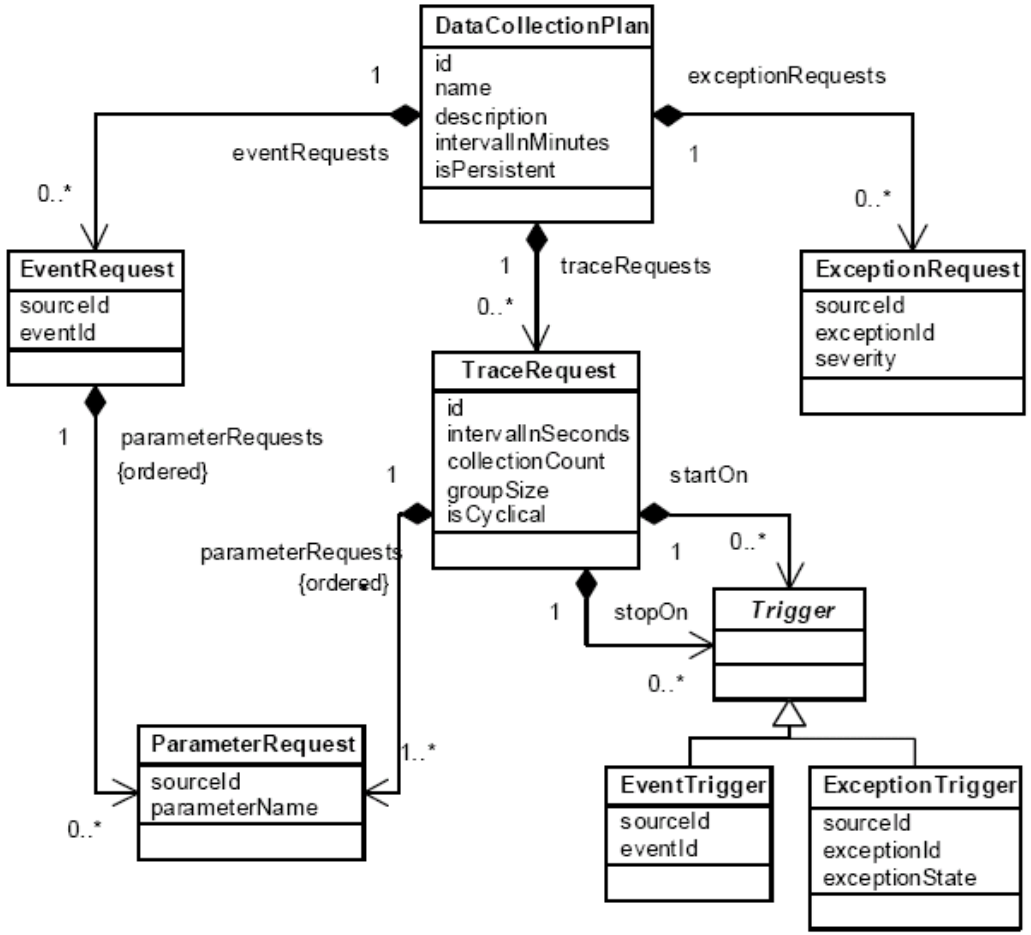
E134 Context



Data Collection Plan

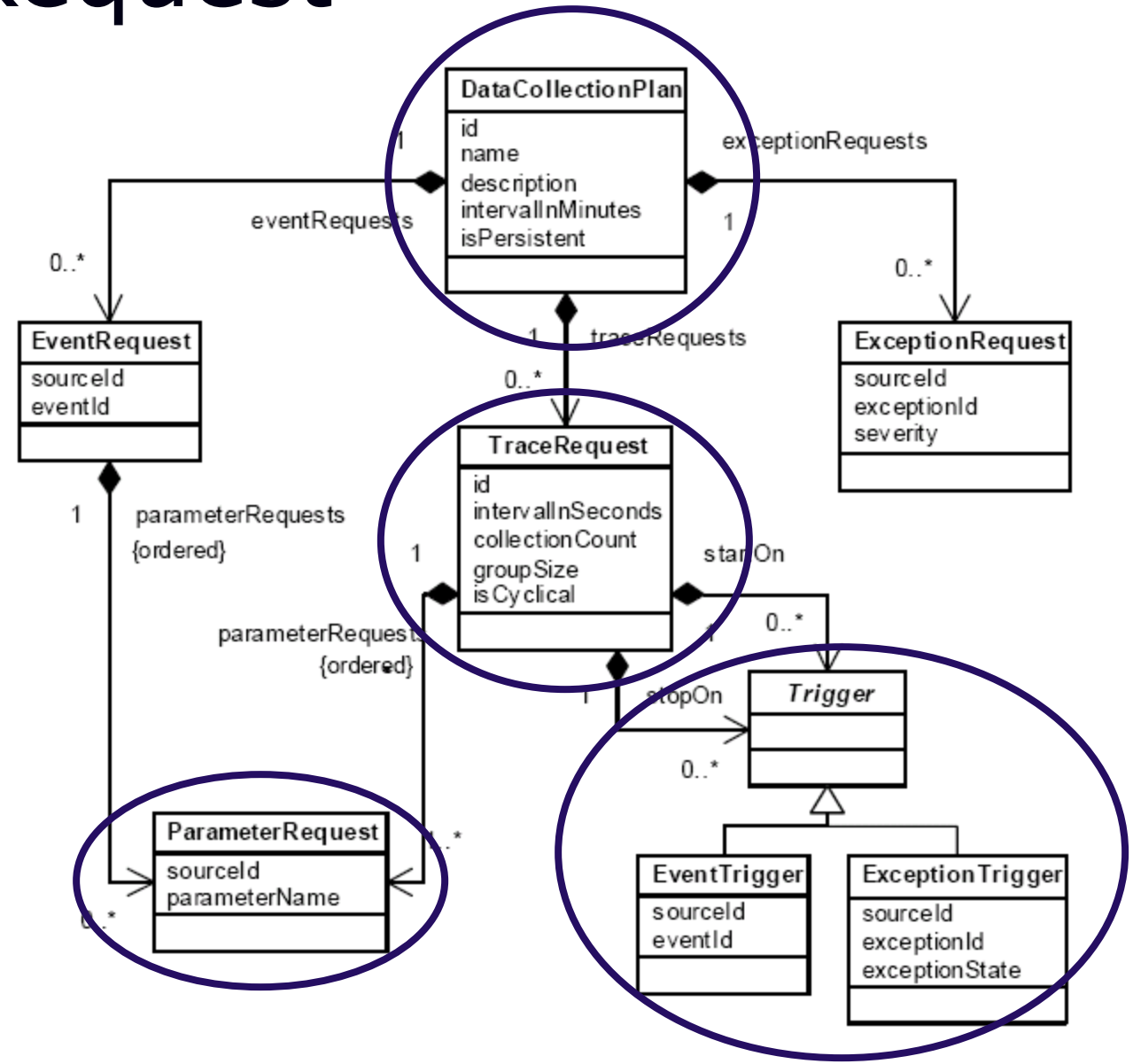
- A Data Collection Plan (DCP) is the specification to send equipment data to the EDA client
- The Client defines a *Request*
- The equipment delivers *Reports*



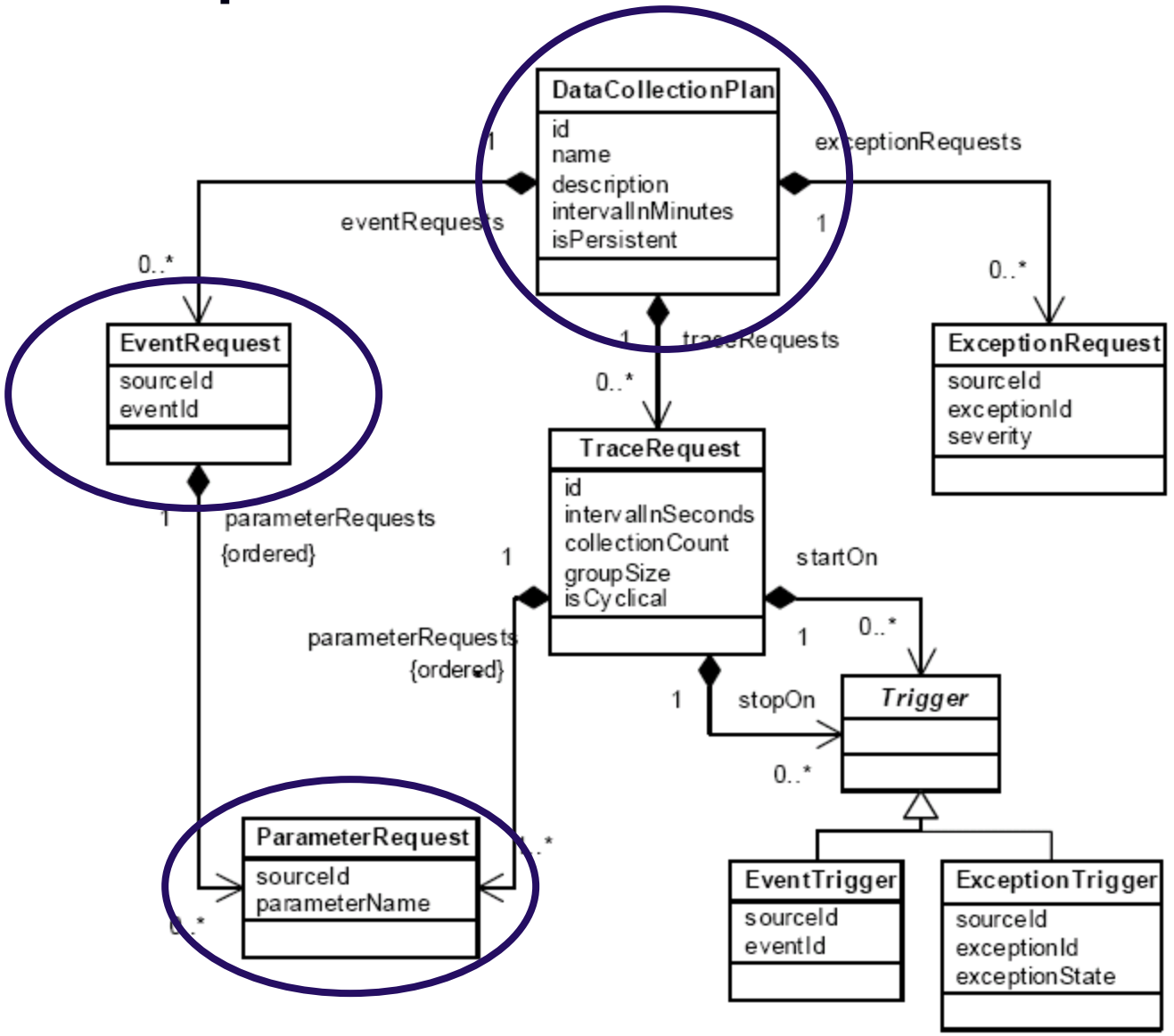
Types of Requests

- Trace
  - Collects data on an Interval
  - Can use Event or Exception as Start/Stop Triggers
    - In 0710, a trigger can have a Condition that evaluates a parameter
    - such as “stepNumber > 10”
  - Can specify Group Size for buffering
- Event
  - Can include transient data associated with the event
  - Can include any non-transient data
- Exception
  - Select exception by any combination: ID, Severity, Location
  - Set or Clear
  - Associated data, if any, is predefined by the equipment

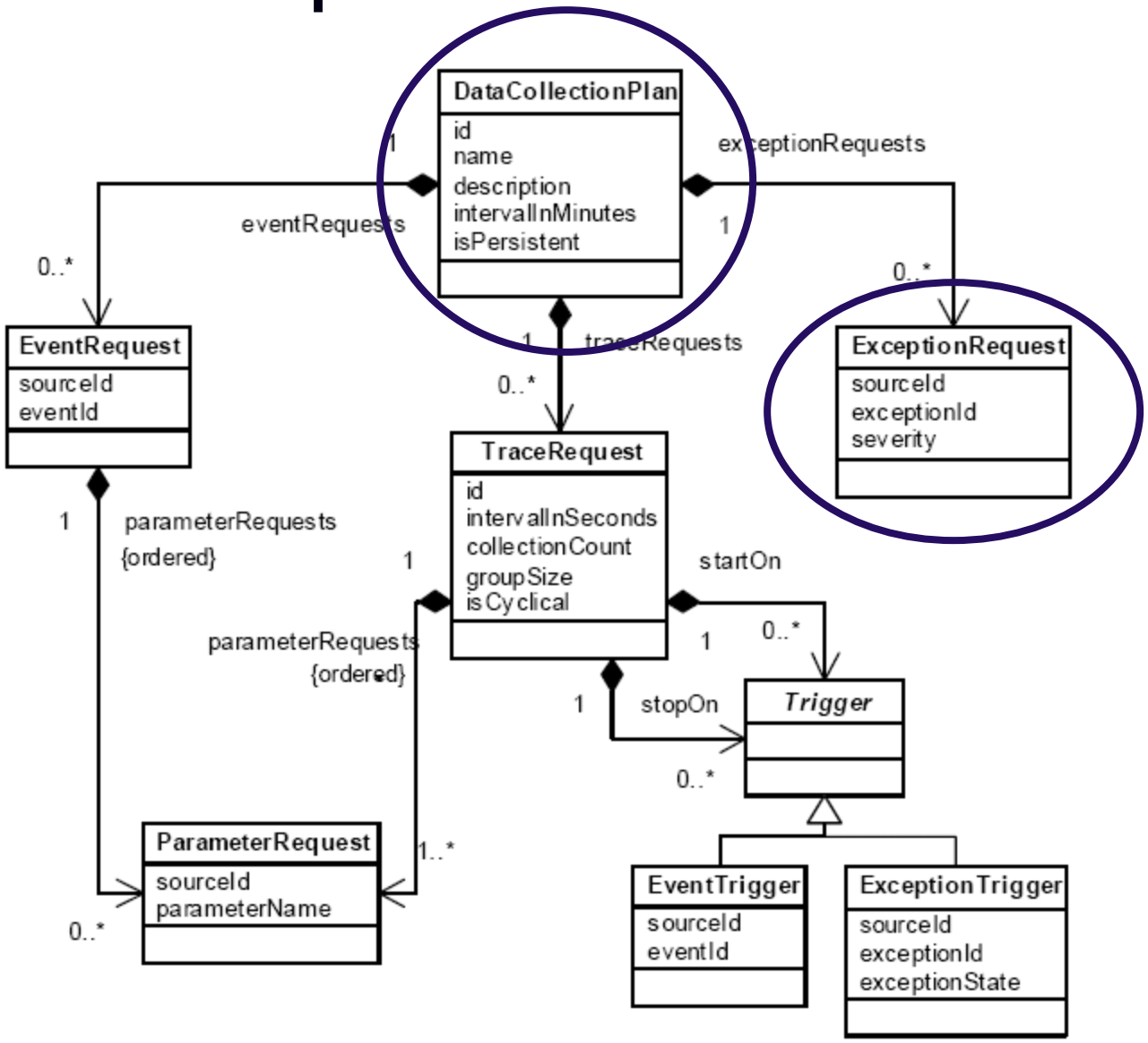
Trace Request



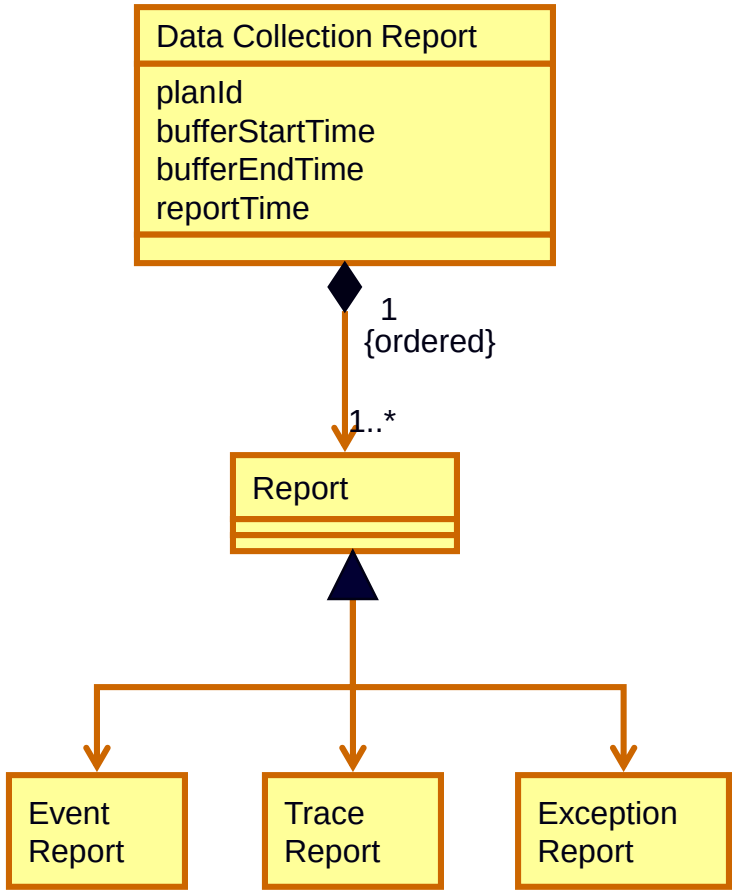
Event Request

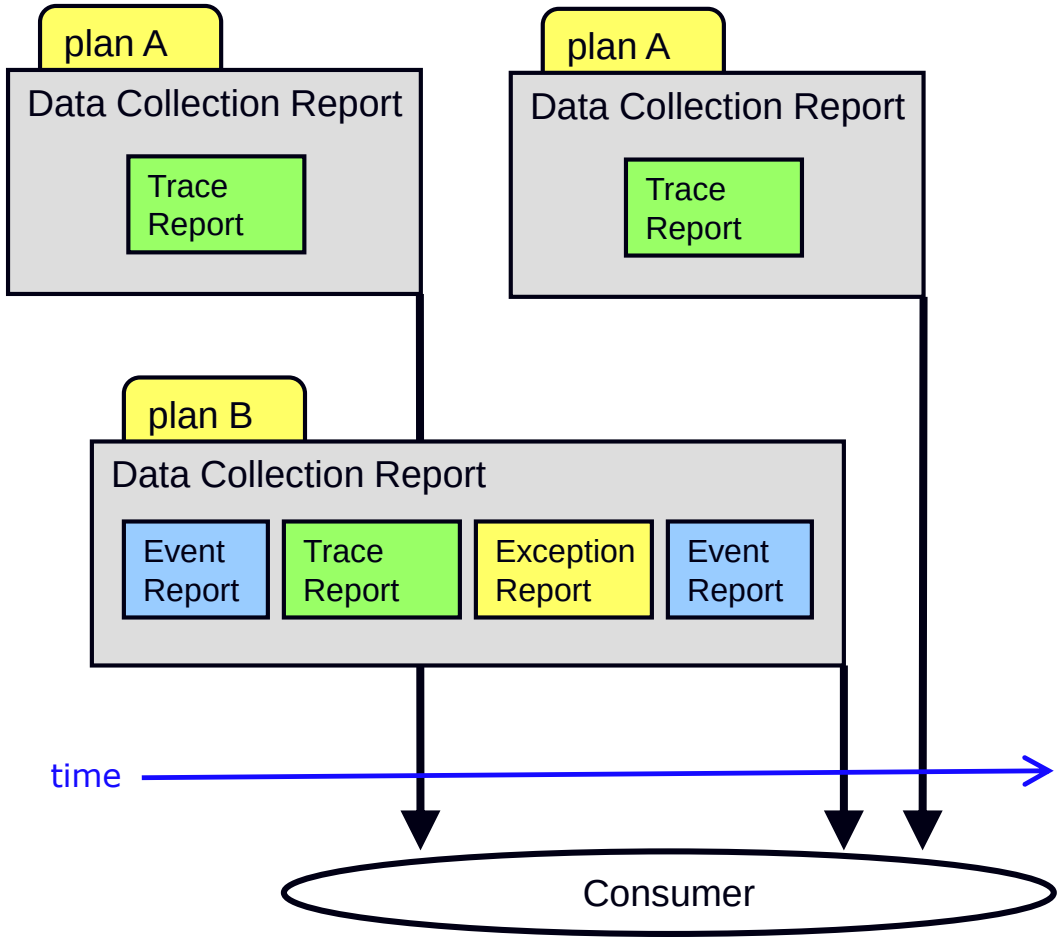


Exception Request



Data Collection Report





E134 – Equipment Services

- DefinePlan
  - Submit a Data Collection Plan (DCP); a set of trace requests, event requests and/or exception requests.
- GetDefinedPlanIds
  - Request a list of all Data Collection Plan IDs.
- GetPlanDefinition
  - Retrieve the definition of a Data Collection Plan
- ActivatePlan
  - Activate the defined DCP
- GetActivePlanIds
  - Request a list of all activated DCP IDs

E134 – Equipment Services

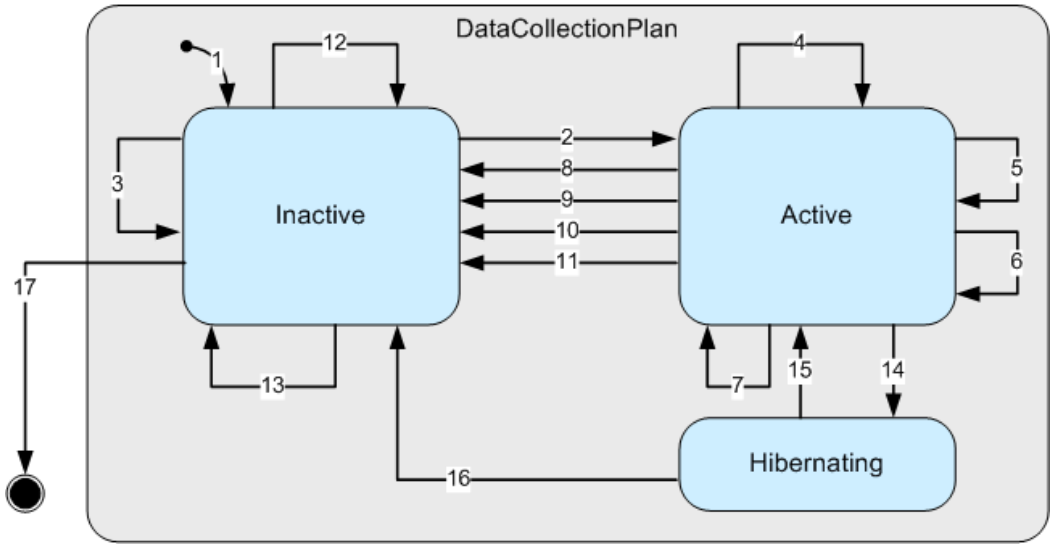
- DeactivatePlan
  - Deactivate the DCP
- DeletePlan
  - Delete a DCP
- GetParameterValues
  - Ad-hoc request to retrieve the current values of one or more E125 parameters.
- GetObjTypeInstanceIds
  - Request a current list of unique instance IDs for one or more E39 ObjTypes.

E134 – Equipment Services

- GetCurrentPerformanceStatus
  - Retrieve the current Equipment performance status.
- GetCurrentDateTime
  - Request the current date and time on the equipment. This is available only in version 0710 and later.

E134 – Client Services

- NewData
  - Data Collection Report from an active DCP. This includes trace, event and/or exception data.
- DCPDeactivation
  - Notification that an active DCP for that consumer is deactivated.
- DCPHibernation
  - Notification when one or more persisted DCP are put into the hibernation state as part of Equipment shutdown.

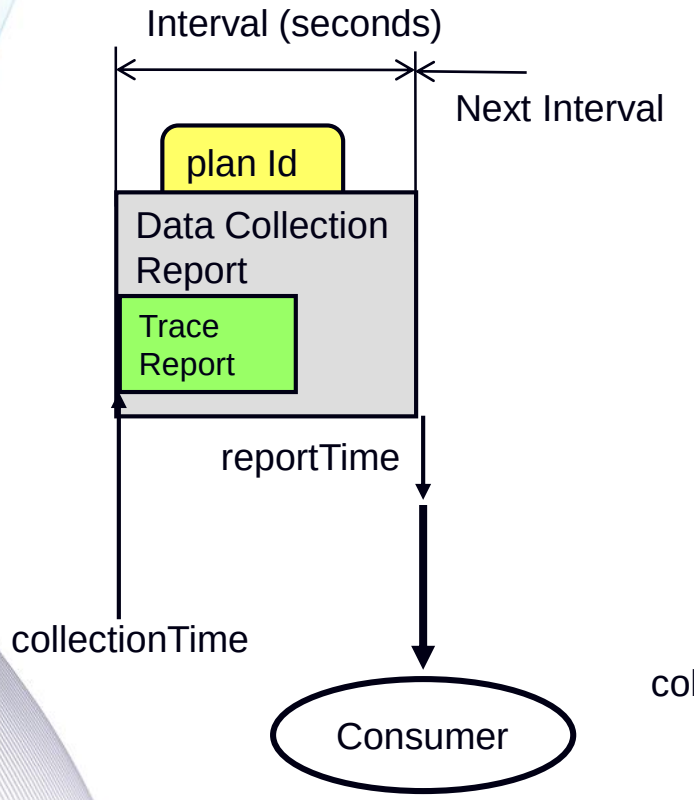


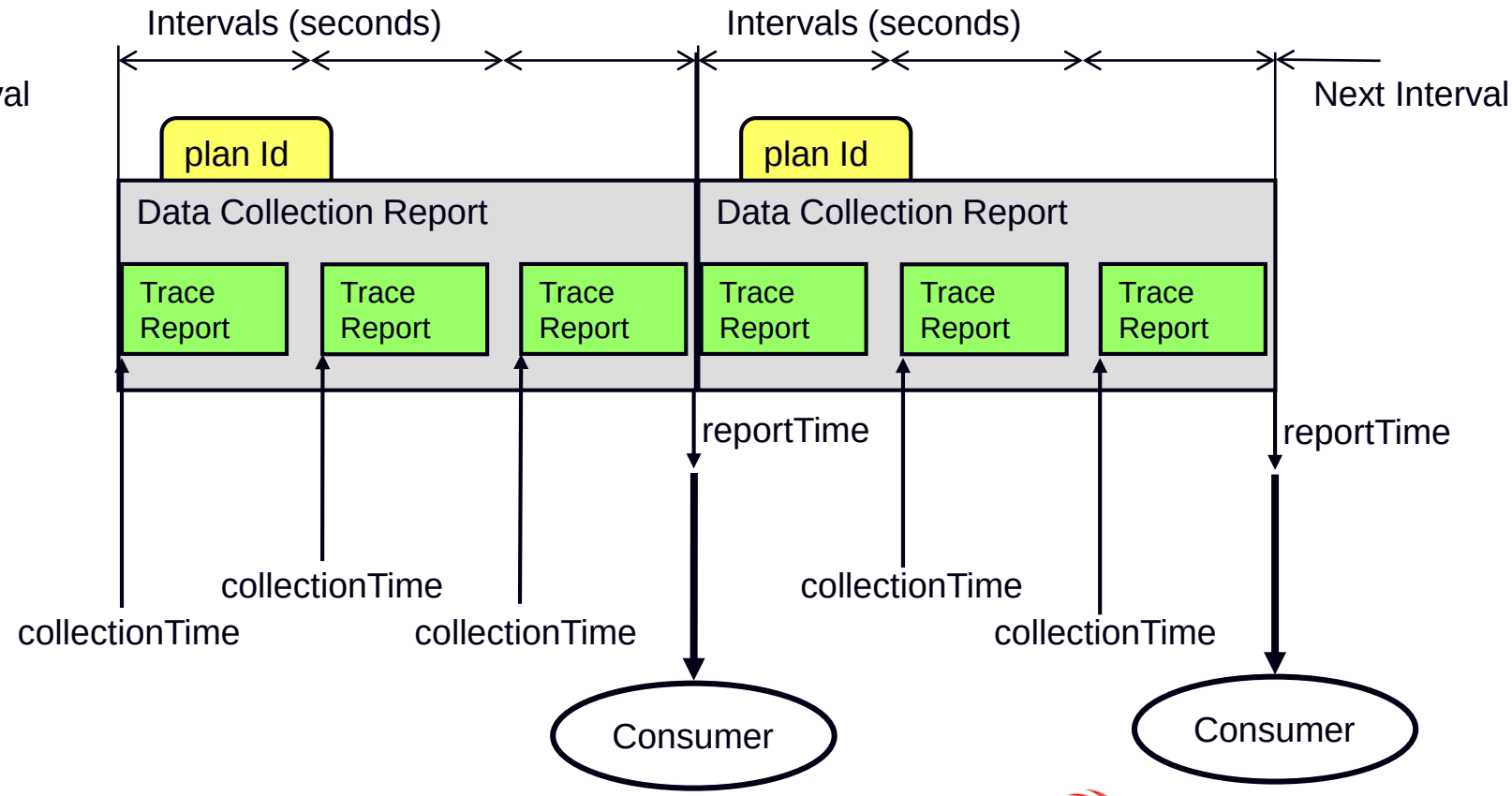
E134 – Client Services

- PerformanceWarning
  - The Equipment detected performance degradation.
- PerformanceRestored
  - The Equipment has detected a return to normal conditions.
- DCPDefined
  - Notification when a DCP is defined by another client. This is available only in version 0710 and later.
- DCPDeleted
  - Notification when a DCP is deleted by another client. This is available only in version 0710 and later.

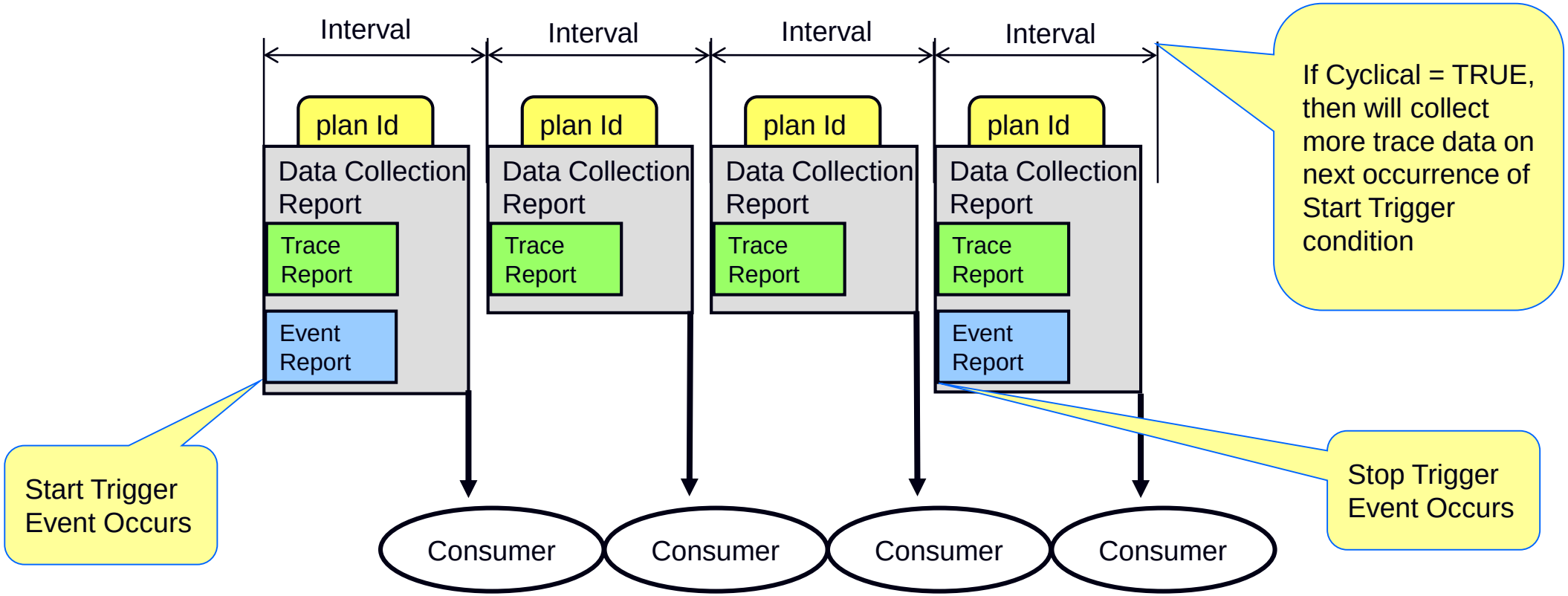
Trace Report Group Size

- Group Size = 1
- Group Size = 3





Trace Report Start/Stop Triggers



Data Collection Report Buffering