Lecture 17, May 6, 2026

ECS 235B, Foundations of Computer and Information Security

Spring Quarter 2026

The Evaluation Classes

- C1, Discretionary Protection
  - Minimal functional requirements for identification, authentication, and discretionary access controls
  - Minimal assurance requirements for testing, documentation
  - Used only briefly, at beginning of the use of TCSEC
- C2, Controlled Access Protection
  - Functional requirements include object reuse, auditing
  - Assurance requirements require more stringent security testing
  - Most commonly used class for commercial products

The Evaluation Classes

- B1, Labeled Security Protection
  - Functional requirements include mandatory access controls, possibly restricted to specified set of objects, labelling to support this
  - Assurance requirements include more stringent security testing, informal model of security policy shown to be consistent with its axioms
- B2, Structured Protection
  - Functional requirements include mandatory access controls for all objects, labeling expanded, trusted path for login, enforcement of least privilege
  - Assurance requirements include covert channel analysis, configuration management, more stringent documentation, formal security policy model proven to be consistent with its axioms

The Evaluation Classes

- B3, Security Domains
  - Functional requirements include implementation of dull RVM, additional requirements for trusted path, constraints on code development (modularity, simplicity, layering, data hiding, etc.)
  - Assurance requirements include all of B2 requirements, more stringent testing, more requirements on DLTS, administrator's guide, design documentation
- A1, Verified Protection
  - Functional requirements are same as for B3
  - Assurance requirements include using formal methods in covert channel analysis, design specification, verification, correspondence between code and FTLS, as well as trusted distribution and increased test and design document requirements

The Evaluation Process

- Evaluators were government sponsored
- Evaluations had no fees for vendors
- Three phases
  - Application
  - Preliminary technical review
  - Evaluation

The Evaluation Process

- Application phase: vendor applied for evaluation
  - If government did not need product, application could be denied
- Preliminary technical review phase: discussions of evaluation process, schedules, development process, etc.
  - This determined when to provide evaluation team, and the basic evaluation schedule
- Evaluation phase: 3 parts, each part's results presented to technical review board (TRB), which approved that part before next part began
  - Design analysis part
  - Test analysis part
  - Final review

The Evaluation Process

- Design analysis part: rigorous review of system design based on provided documentation
  - Source code not reviewed
  - Stringent requirements on completeness, correctness of documentation
  - Initial product assessment report produced in this part
- Test analysis part: test coverage assessment, vendor supplied tests run
- Final review part: after approval of previous parts, a final evaluation report produced and given to TRB
  - When that approved final evaluation report, rating awarded

Ratings Maintenance Program (RAMP)

- Maintained assurance for new versions of evaluated product
- Vendor updated assurance evidence
- TRB reviewed report; when approved, new version given evaluation rating
- Vendor had to have trained Vendor Security Analyst on staff to perform RAMP process
- Not all enhancements were accepted by RAMP
  - For example, structural changes could require new evaluation

Impacts

- TCSEC was first evaluation technology
  - Created new approach to determining how secure a product is
  - Developed ideas of evaluation classes, assurance requirements, assurance-based evaluation
  - Technical depth of evaluation came from strength of foundation of requirements and classes, rigor of evaluation process, rigor of review
- Issues with TCSEC
  - Evaluation process difficult, often lacked enough resources
  - Functionality, assurance blended together in evaluation classes
  - Limited scope

Limitations of Scope

- Written for operating systems and does not translate well to other types of systems
- Focused on needs of US government
- Did not address integrity, availability, other business-critical applications
- National Computer Security Center developed criteria for other systems based on TCSEC
  - Trusted Network Interpretation (TNI), released in 1987
  - Trusted Database Management System Interpretation (TDI), released in 1992
  - Not many evaluations under these

Limitations of Process

- Requirements defining evaluation classes gradually expanded
  - Called *criteria creep*
  - Sometimes had to interpret requirements to apply them to specific products; these were published as informal addenda
  - Class requirements became union of TCSEC requirements and applicable interpretations
  - So as time passed, systems had to meet more stringent requirements

Limitations of Process

- Evaluations took too long
  - Many vendors misunderstood depth of evaluation, required interactions with evaluation teams
  - Way evaluations were done caused misunderstandings, scheduling problems
  - Vendors often lacked motivation to complete free evaluation
- Some evaluations took so long, product's end of life came before evaluation completed
- Towards end of TCSEC, government approved commercial labs as evaluators; charged a fee for evaluation
  - Reduced time problem with evaluations completing in around a year

Contributions

- Provided a process for security evaluation of products
  - Helped commercial sector realized need for computer security
- Its inadequacies led to development of new approaches and methodologies for evaluation

Information Technology Security Evaluation Criteria (ITSEC)

- Many countries created their own evaluation criteria
  - Canada, France, Germany, the Netherlands, the United Kingdom
  - Not reciprocal, so one product evaluated by each separately
- European Union standard developed to harmonize all these criteria
  - Result: ITSEC, published in 1991, EU endorsed it in 1995
  - Used until mid-2000s, until Common Criteria developed
- Different approach than TCSEC

Evaluation Basics

- Vendor provided functional criteria
  - *Security target* (ST) defined security functional criteria
  - Advantage: ITSEC could be used on any type of system
- *Target of evaluation* (TOE) is system, associated documentation, that is subject of evaluation
- UK defined exemplary sets of functional requirements
  - Systems certified as functional class and assurance class (eg, FC2-E3)

Assurance Requirements

- Defined within constraints of evaluation levels
- Effectiveness requirements for security target included:
  - Suitability of requirements: addressed consistency and coverage of security target
  - Binding of requirements: analyzed security requirements, mechanisms that implemented them

Assurance Requirements

- Requirements for TOE
  - Assessment of security measures used for *developer* environment during development, maintenance of TOE
  - Correspondence must be defined between all levels of representation in TOE
  - Required source code at several levels, object code at highest level
  - Distribution requirements at all levels
  - Vulnerability analysis required at design level
  - Ease of use analysis examined how system might be misused based on study of system documentation
  - Strength of mechanisms effectiveness requirement applied to each mechanism whose strength could be measured

Evaluation Levels

- E1, E2, E3, E4, E5, E6; E0 for products not meeting other levels

E1: requires ST, informal description of system, testing of system to show it satisfied ST

E2: E1 + informal description of detailed design, configuration control, distribution control process, evidence of testing

E3: E2 + more stringent requirements on detail design, correspondence between source code and security requirements

Evaluation Levels

E4: E3 + formal model of security policy, structured approach to design, design level vulnerability analysis

E5: E4 + correspondence between detailed design and source code, source code level vulnerability analysis

E6: E5 + use of formal methods

- Example: architectural design must be stated formally, shown to be consistent with formal model of security policy

Evaluation Process

- Each country had its own methodology for doing evaluations
  - This is the UK methodology
- Certified licensed evaluation facilities (CLEFs) evaluated for a fee
  - In turn, these certified by UK government
  - Also did consulting to help vendors prepare for evaluation
- Began with evaluation of security target (ST); once ST approved, product evaluated against the ST
- Certificate maintenance scheme required plan, evidence to support correct implementation of plan

Process Limitations

- Some considered using same company for evaluation preparation and the evaluation itself a conflict of interest
  - Different divisions of company, but could still have similar biases
- Usually 1 or 2 people made the decisions, and review of them was insufficient
- No body of experts to approve evaluator design analysis and test coverage analysis
  - Government body provided final approval of evaluation, but generally followed recommendation of evaluation team

Vendor-Provided Security Targets

- Vendors often did not have the expertise to develop appropriate security targets
  - Usually work of 1 or 2 people
  - No official review assessed quality of the ST
  - These were ameliorated by use of predefined functionality classes
- So some concern that ITSEC evaluations did not check that claims made sense
  - Just verified product met claim

Impacts

- Evaluation allowed flexibility in defining requirements and mixing functional and assurance requirements
- Use of commercial labs made evaluation process quicker
- Methodology allowed any type of product to be evaluated
- ITSEC evaluations often considered weaker than those of TCSEC
  - Development of functional requirements has potential weaknesses
  - Evaluation process itself not so rigorous as that of TCSEC
- No reciprocity of evaluations with US, Canadas

Federal Criteria

- NSA, NIST developed Federal Criteria (FC) to replace TCSEC with new evaluation approach
  - FC had catalogue of functional requirements
- *Protection profiles* (PP) identified requirements, other information particular to family of systems
  - An abstract specification of security aspects of an IT product
  - Product independent, describing range of products
  - Functional, assurance requirements bound together with rationale describing threats, intended method of use

FC Requirements

- Catalogue of functional requirements
  - All functional requirements of TCSEC
  - Requirements from CSIR included system entry constraints, others
  - Requirements for resource allocation, fault tolerance (availability)
  - Requirements for security management
- Assurance requirements
  - Met both TCSEC, ITSEC requirements
  - New assurance requirement for life cycle process

Impacts

- Contributed concept of protection profile
  - PP requirements selected from FC functional requirements catalogue
- PP included
  - Information for identification, cross-referencing
  - Description of problem that profile addressed
  - Rationale portion included threats, environment, assumptions, justification
- FC supported evaluation of protection profiles
- Development of profile registry making FC-approved PPs for general use

FIPS 140: Cryptographic Modules

- Standard for evaluating cryptographic modules
  - Sponsored by NIST, Canadian Security Establishment under the Cryptographic Module Validation Program (CMVP)
- ”Module” is set of hardware, firmware, software that implements cryptographic logic or processes
  - If done in software, processor included in cryptographic module
  - Evaluation of software modules includes operating system
- Cryptographic Algorithm Validation Program (CAVP) provides for evaluation of approved crypto algorithms against specific algorithm specifications
  - List of approved crypto algorithms is dynamic
  - CMVP requires validation testing be performed by CAVP

FIPS 140 Security Levels

- FIPS 140-2 is current standard; 4 security levels
- *Security level 1*: encryption algorithm is to be FIPS-approved algorithm; must be executed on production-grade equipment
  - For example, a general-purpose computer using unevaluated operating system
- *Security level 2*: requirements for security level 1, plus:
  - Physical security: tamper-evident coatings or seals or pick-resistant locks
  - Provides for role-based authentication
  - Allows software cryptography in multiuser systems when used with operating system evaluated at EAL2 or better in Common Criteria

FIPS 140 Security Levels

- *Security level 3*: requirements for security level 2 plus:
  - Enhanced physical security (available in many commercial products)
  - Identity-based authentication
  - Underlying operating system is EAL3 under specific Common Criteria PP
- Security level 4: requirements for security level 3 plus:
  - Physical security: envelope of protection around crypto module to detect. respond unauthorized attempts at physical access
  - Protection against compromise from environment
  - Software, firmware components of module can be executed on general-purpose operating system meeting EAL4 or higher

FIPS 140-2 Documentation

- Validation testing of modules uses Derived Test Requirements (DTR) for FIPS 140-2
  - Contains all vendor, certification laboratory requirements for validating module
- Implementation Guidance (IG) provides programmatic guidance of CMVP
  - Contains clarification, guidance for DTR
  - Testing, implementation guidance of Approved, non-Approved functions
  - Guidance on how validated software, firmware can be ported to similar environment and retain its validation

Impact

- Improved quality, security of cryptographic modules
- 164 modules tested by 2002, about half had security flaws; 95% had documentation errors
  - Vendors fixed these before deployment, use
- 332 cryptographic algorithms tested by 2002, about 25% had security flaws; more than 65% had documentation errors
  - Vendors fixed these before deployment, use
- By 2018, more than 1100 cryptographic modules, more than 7000 cryptographic algorithms validated

Common Criteria (CC)

- Joint project of several nations
  - US, Canada, UK, France, Germany, Netherlands, others
- Version 1.0 published in 1994
- CC *de facto* standard in US in 1998
  - TCSEC retired in 2000

Common Criteria (CC)

- Arrangement on the Recognition of the Common Criteria Certifications in the Field of Information Technology Security
  - First signed in 1998 by US, UK, France, Germany, Canada
  - Australia, New Zealand signed in 1999
  - As of 2017, 28 nations in the CCRA
- Expanded to allow nations to join as authorizing (certification producing) and/or consuming (certification recognizing) members
  - As of 2017, 17 authorizing nations including the US, UK, Australia, Canada, France, Germany

CC Methodology

- CC Documents
  - Provide overview of methodology, functional and assurance requirements, Evaluation Assurance Levels (EALs)
- CC Evaluation Methodology (CEM)
  - Provides detailed guidelines for evaluation at levels EAL1–EAL4, commonly used assurance requirements not in any EAL
  - EAL1–EAL4 are low to medium trust; EAL5–EAL7 are high assurance
- Evaluation Scheme (or National Scheme)
  - Provide infrastructure necessary to implement CC evaluations
  - Each country does this in its own way

Evaluation (National) Schemes

- CC documents, CEM set fundamental criteria, EALs, evaluation strategy
- Countries may have different methods of selecting evaluators, structuring interactions between vendors and evaluators, awarding certifications, etc.
  - Example: in US, National Institute of Standards and Technologies (NIST) implements Common Criteria Evaluation and Validation Scheme (CCEVS); NIST accredits commercial labs to do the evaluations; NIST then validates the evaluation and awards the EALs

Terms

- *TOE Security Policy* (TSP): set of rules regulating how assets are managed, protected, distributed within a system
- *TOE Security Functions* (TSF): all hardware, firmware, software of the system that must be relied on for correct enforcement of TSP
  - Generalizes concept of TCB

Evaluation of Protection Profiles (PP)

- *CC Protection Profile*: implementation-independent set of security requirements for category of systems that meet specific consumer needs
- PP has 6 sections
  - Introduction
  - Conformance claims
  - Security problem definition
  - Security objectives
  - Extended components definition
  - Security requirements

Structure of Protection Profiles (PP)

- *Introduction*; contains PP reference information, TOE overview
- *Conformance claims*: does PP claim conformance to any other PPs, packages
  - *Strict conformance*: requires evidence all PP requirements are met and ST or PP claiming conformance is instantiation of the PP while allowing ST or PP claiming conformance to be broader than itself
  - *Exact conformance*: requires ST claiming conformance use exact same security requirements (type of strict conformance)
  - *Demonstrable conformance*: requires evidence that ST/PP claiming conformance solves generic security problem described in PP

Structure of Protection Profiles (PP)

- *Security problem definition*: presents
  - *Assumptions* about intended use, environment of use
  - *Threats* to assets requiring protection; threat agents, type of attacks, assets that are targets of attacks
  - *Organizational security policies* that the product must abide by
- *Extended components definition*: defines components needed in a PP not defined in CC

Structure of Protection Profiles (PP)

- *Security objectives*: defines security objectives, rationale
  - *Security objectives for the TOE* must be traced back to identified threats, organizational policies
  - *Security objectives for the operational environment* must be traced to threats not completely countered by system, organizational policies, assumptions not met by system

Structure of Protection Profiles (PP)

- *Security requirements*: functional, assurance requirements
  - *Security functional requirements* (SFR) usually drawn from CC, or supplied by author
  - *Security assurance requirements* may be based on EAL
  - *Security requirements rationale* demonstrates requirements are traceable to, and meet, security objectives

PP-Module

- Uniquely referenced construct defining a set of elements addressing optional set of security features added to base product type
  - Must refer to at least one Base-PP providing mandatory requirements and base TOE type
  - Complements security problem definition, objectives, requirements of Base-BB by adding new elements or giving more detailed set of elements
  - Must be evaluated as part of PP-Configuration

PP-Configuration

- Composite of one or more PP-Modules with associated Base-PP
- Cannot have additional content not found in selected PP-Modules or Base-PPs
- Evaluation rules for these based on evaluation rules for standard PPs

Evaluation of System against Security Target

- First part: evaluation of ST in accordance with assurance class ASE: Security Target Evaluation
- Second part: evaluation of system against ST
- *Security target*: implementation-dependent set of security requirements and specifications to be used as basis for evaluation of identified system

Structure of the Security Target

- ST consists of 7 sections
  - ST introduction
  - Conformance claims
  - Security problem definition
  - Security objectives
  - Extended component definition
  - Security requirements
  - TOE summary specification

Structure of the Security Target

Introduction section has 4 parts

- *ST reference*: precise information used to control, identify the ST
- *TOE reference*: precise information used to control, identify system to which ST refers
- *TOE overview*: brief description of TOE acceptable as abstract for use in evaluated product lists; also states type of TOE (router, firewall, OS, etc.)
- *TOE description*: more detailed description of TOE to aid in understanding its security requirements

Structure of the Security Target

Conformance claims section has 4 parts

- *CC Conformance claims*: statement of conformance to CC
  - *Part 2 (3) conformant: uses only functional requirements from CC part 2 (3)*
  - *Part 2 (3) extended*: also uses extended requirements defined by vendor
- *PP claim*: list of PPs to which ST is conformant
- *Package claim*: identifies packages (EALs) to which ST claims conformance
  - *Conformant*: security functional, assurance requirements identical to those in package
  - Augmentation: security functional, assurance requirements of ST include all those of package plus at least 1 additional requirement

Structure of the Security Target

Conformance claims section has 4 parts

- *CC Conformance claims*: statement of conformance to CC
  - *Part 2 (3) conformant: uses only functional requirements from CC part 2 (3)*
  - *Part 2 (3) extended*: also uses extended requirements defined by vendor
- *PP claim*: list of PPs to which ST is conformant
- *Package claim*: identifies packages (EALs) to which ST claims conformance
  - Conformant: security functional, assurance requirements identical to those in package
  - Augmentation: demonstrates TOE type consistent with claimed PP, security objectives, requirements are consistent with those of claimed PP

Structure of the Security Target

Conformance claims section, 4th part

- *Conformance rationale*: show the following:
  - TOE type consistent with claimed PP
  - Security problem definition (SPD) in ST is consistent with that in claimed PP
  - Security objectives in ST are consistent with those in claimed PP
  - Security requirements in ST are consistent with those in claimed PP

Structure of the Security Target

Security Problem Definition: includes

- *Assumptions* about intended usage, environment of use
- *Threats* to assets requiring protection in terms of threat agents, types of attacks, targets
- *Organizational security policies* that the system must respect

Structure of the Security Target

Security Objectives: two types of objectives

- *Security objectives for the TOE* must be traced back to aspects of identified threats, organizational policies
- *Security objectives for the operational environment* must be traced back to threats, assumptions, organizational policies not completely met or countered by system
- Security objectives rationale shows security objectives counter threat, meet assumptions, enforce organizational security policy

Structure of the Security Target

Extended components definition defines components in ST not defined in CC Parts 2 and 3

- New definitions must be modeled after existing CC Part 2 components

Structure of the Security Target

Security Requirements cover functional, assurance requirements

- *Security functional requirements* drawn from CC Part 2
  - If none appropriate, ST author can supply others
- *Security assurance requirements* drawn from CC Part 3, may be based on an EAL
  - Author may add extra security assurance requirements from CC or may supply others, including security requirements for environment
- *Security requirements rationale* shows requirements for system, environment traceable to and meet objectives
- *Justification* for any security requirement dependencies not satisfied

Structure of the Security Target

TOE Summary Specification defines instantiation of system security requirements

- High-level description of how TOE meets claimed security functionsl requirements
- High-level description of how TOE protects itself from interference, logical tampering, bypass

CC Requirements

- Requirements divided into classes based on common purposes
- Classes broken into families
- Families made up of components
  - Definitions of detailed requirements, dependent requirements, definition of hierarchy of requirements
- Functional requirements
- Assurance requirements
  - EALs built from these

CC Security Functional Requirements

11 classes, each with at least 1 family; family has:

- Management section with specific information about management issues for subdivisions, requirements of family
- Audit section identifies auditable events
- Hierarchical dependencies
  - Requirement A hierarchical to requirement B if A's functional requirements offer more security, or is more restrictive, than those of B
- Nonhierarchical dependencies also identified
  - May cross classes

CC Security Functional Requirements Classes

- FAU: Security Audit; 6 families
  - Audit automatic response, data generation, analysis, review, storage
- FCO: Communication; 2 families
  - Nonrepudiation of origin, receipt
- FCS: Cryptographic Support; 2 families
  - Cryptographic key management, operation
- FDP: User Data Protection, 13 families
  - Access control policies, information flow policies; object reuse, data authentication, rollback, stored data integrity