Review: MAC

• Mandatory access control (MAC)
  – not Message Authentication Code (applied crypto), nor Media Access Control (networking)
  – philosophy: central authority mandates policy
  – information belongs to the authority, not to the individual users

• Five case studies:
  1. Multi-level security (military)
  2. Brewer-Nash (consulting firm) // in the middle of this
  3. Role-based access control (organization)
  4. Clinical information systems (medicine)
  5. Clark-Wilson (business)
3. ROLE-BASED ACCESS CONTROL
Jobs

• Your access rights depend on job you are performing
  – Student in one class
  – TA in another class
  – Prof in another class?

• Existence of jobs is relatively stable in organization
  – Even if over time the people who perform them change jobs
  – Better not to directly assign rights to user

• Instead, associate rights with the job...
Roles and rights

**Role:** job function or title

- Users are assigned to roles
- Subjects executing on behalf of users can activate a role to indicate it is now performing that job
  - Least Privilege
  - Amplification of Privilege
Roles and rights

• Roles can be hierarchical
  – e.g. TA, prof
  – Hierarchy is a *partial order*

• Multiple roles may be active simultaneously

• Can be *constraints* on which roles users can simultaneously be assigned
  – e.g. cannot be both Student and TA in same course
  – provides possibility for Separation of Duty
Roles and rights

• **Rights:**
  – Rights are assigned to roles, not directly to users
  – Relation on (role, obj, rights)

• **Role-based access control (RBAC) policy:** role assignment plus rights assignment
Roles vs. groups

- **Group:**
  - set of users
  - can be assigned rights

- **Role:**
  - set of users
  - can be assigned rights

- **Differences?**
  - Roles are hierarchical and can inherit rights
  - Roles can be activated and deactivated
RBAC, DAC, MAC

Is RBAC a DAC or MAC policy?

• Role assignments typically dictated by organization: MAC

• Right assignments might come from organization or from owners of objects: MAC or DAC
4. CLINICAL INFORMATION SYSTEMS
Medical systems

US:

• Privacy became a concern in medical information systems ca. mid 1990s

• 1996: Health Insurance Portability and Accountability Act (HIPAA)

• No one’s happy:
  – privacy advocates consider it inadequate
  – hospitals complain it raises costs
  – patient advocates report it’s used by hospital staff as an excuse to be unhelpful
Medical systems

UK:
• 1995-6: attempt by government to centralize all medical records
  – single electronic record that follows you from conception to autopsy
  – security was going to be based on MLS, but that wasn't a good match: e.g., what security level should prescriptions be?
• British Medical Association (BMA) engaged security researchers to develop a policy for clinical information systems
• BMA model [Anderson 1996]
  – guided by stated ethics of medical societies, and advice of practicing clinicians
  – adopted by Union of European Medical Organizations in 1996
  – pilot implementations fielded in private practice and hospital systems in England in late 1990s
BMA model

• Patient: individual who is subject of medical records
  – or an agent for that person who can give consent to be treated
  – patients who are mentally incapacitated, unconscious, or dead: "it's complicated"

• Medical records: information about health, history, or treatment that identifies patient
  – assumes records are about a single individual; obstetrics/gynecology are not

• Clinician: health-care professional who has access to medical records
  – licensed, bound by professional obligation of confidentiality: "Patients have a right to expect that you will not pass on any personal information which you learn in the course of your professional duties, unless they agree." [General Medical Council]
  – e.g. doctor, nurse, dentist, pharmacist
  – debates over whether telephone staff, social workers, etc. are included
BMA access control

• A patient may have many medical records
  – Many records within a practice
  – Many practices at which a patient

• **Access control lists**: each medical record (object) has an ACL
  – Identifies which clinicians (subject) have access
  – Only clinicians may be on the ACL, not administrators, lawyers, police, insurance company, employer, ...
  – Being on ACL conveys right to **read and append**
  – No read-only access: auditors and researchers who would need this instead get full access to a temporary copy of record
BMA access control

- **Groups:**
  - Clinicians work in teams, so subjects in ACL might be groups
  - Static, e.g., all the clinicians at a small practice
  - Dynamic, e.g., any clinician on duty in patient's ward
- **Altering the ACL:**
  - One clinician on ACL is marked as responsible
  - Only responsible clinician may alter ACL
- **Patient's access:**
  - Patient does have read access to own record
  - And "append objection" access
  - In practice these not supported by software
BMA record management

Creation

• Can occur when:
  – New patient registers at a practice
  – Patient is referred from another practice
  – Patient wants to discuss a new highly sensitive condition

• Clinician creates record
  – That clinician is added to the ACL (and presumably marked responsible)
  – Any referring clinician also added to ACL
BMA record management

Access

• Each record carries log of access (read or append) with the subject's identity, date, and time

• Possible to reconstruct record as it existed at any point in time

• Life-critical entries in record require special approval, e.g., Do Not Resuscitate order
BMA record management

Copy between records

• Clinician might want to append information derived from record A to record B

• Permitted if B's ACL is a subset of A's
  – May restrict the set of readers
  – Similar to "no write down" in MLS: can't make information more public

• Or permitted if patient gives consent
  – Similar to declassification by trusted subject in MLS
BMA record management

Copy between records

• Instead of copying, might want to enter into record B "see record A"

• But indicating presence of secret records can itself violate consent

• Example from Netherlands:
  – Implementation: when patient diagnosed with cancer, records removed from computer system.
  – Result: insurers inferred patient had cancer when they saw a blank record

• Possible solution: flag in record to prompt clinician to ask "is there anything else you want to tell me?"
BMA record management

Deletion

• No information may be deleted from record
• Most primary records must be kept for 8 years
  – Some records kept longer, esp. cancer and genetic diseases
  – Clinicians certainly want to keep records until after malpractice suit could be brought
• Can patients insist that their record be destroyed?
BMA consent and notification

• Responsible clinician must obtain consent from patient when:
  – Record is created
  – ACL is modified
  – Responsibility is transferred
• And in each situation notify patient of subjects on ACL
• Consent normally obtained in advance
  – But in emergency or statutory situations may be delayed
  – Delayed consent results in after-the-fact notification
    • Typically occurs annually by letter
    • Patient might then detect unauthorized access
BMA aggregation

- Risky to give any one clinician access to too many records: might be corrupted or blackmailed or hacked, compromising privacy
- So patients must receive special notification if such clinician added to ACL
- What's "too many"?
  - Not uncommon for all clinicians at hospital (maybe 2,000) to be able to access all patients (maybe a million or more)
  - But if 300 such hospitals share an information system, that would mean 600,000 staff have access to the entire population of the US (about 300 million)
  - Typical countermeasure is declaration that unjustified access results in dismissal
5. CLARK-WILSON
Commercial systems

[Clark and Wilson 1987]

• Studied commercial systems rather than military

• **Primary goal is integrity, not confidentiality**
  – Prevent fraud
  – Prevent error

• Two main techniques:
  – Well-formed transactions
  – Separation of duty
Commercial systems

Well-formed transactions:

• Transition system from one state to another
• Maintain invariants over state
• e.g. bank teller
  – Trained to perform only certain kinds of transactions from their drawer
  – Maintain invariant: (yesterday's balance) + (today's deposits) – (today's withdrawals) = (today's balance)
• e.g. if error discovered enter a new transaction that accounts for error rather than amending old transaction
Commercial systems

Separation of duty:
• Transactions require multiple principals
• Principals mutually certify that transaction performed properly
• e.g. purchasing:
  – Purchasing agent creates order, sends order to supplier, receiving agent, and accounting
  – Supplier ships goods to receiving
    • Receiving clerk checks goods against original order and updates inventory
  – Supplier sends invoice to accounting
    • Accountant checks invoice against original order
  – All four principals work together to detect fraud and error
Clark-Wilson model

• Two levels of security:
  – **Constrained**: high integrity information, crucial to business, e.g., bank account balances
  – **Unconstrained**: low integrity information, nonessential to business, e.g., gift selected by customer when account opened

• **Constrained data items** (CDIs) are meant to satisfy integrity constraints, e.g. teller balance constraint
  – **Valid** state: all CDIs satisfy their constraints
  – Otherwise **invalid**

• **Unconstrained data items** (UDIs) don't have integrity constraints
Clark-Wilson model

• **Integrity verification procedures (IVPs):**
  - test whether CDIs satisfy constraints, hence state is valid
  - e.g. teller balancing drawer at opening and closing of window

• **Transformation procedures (TPs):**
  - change system from one valid state to another valid state
  - operate on associated CDIs
  - implement well-formed transactions
  - e.g., deposit, withdraw, transfer
Clark-Wilson rules

• Certification rules (CRs):
  – Followed by security officer of business
  – Goal is to certify that system will obey integrity policy
  – Offline checking

• Enforcement rules (ERs):
  – Followed by system
  – Goal is to enforce the integrity policy
  – Online checking
Clark-Wilson rules

Rules for well-formed transactions:

• **CR:** IVPs must ensure that CDIs are in a valid state

• **CR:** TPs must maintain validity as invariant

• **ER:** A TP may modify only its associated CDIs

• **CR:** A TP that accepts UDIs as input must validate them as part of transforming them into CDIs
Clark-Wilson rules

Rules for separation of duty:

• **CR:** Users must be authorized to invoke TPs
  
  *part of what security officer is meant to check as part of this certification is that separation of duty is actually part of the authorization policy*

• **ER:** Only the security officer may change the authorization policy, and the security officer may not invoke TPs

• **ER:** The system must check that authorization policy before performing TPs on behalf of a user

• **ER:** The system must authenticate users

• **CR:** All TPs must append enough audit information to reconstruct the operation to an append-only CDI
Clark-Wilson rules

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Gold standard
Contributions of Clark-Wilson

• Difference of concerns between commercial and military security models
• Separation of duty
• Certification as distinct from enforcement
Recap: MAC

- **Mandatory access control (MAC)**
  - **philosophy:** central authority *mandates* policy
  - information belongs to the authority, not to the individual users

- **Five case studies:**
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Upcoming events

• [today] A5 due, A6 out

"Whatever I shall see or hear in the course of my profession...if it be what should not be published abroad, I will never divulge, holding such things to be holy secrets." – Hippocratic Oath