Securing Applications and Data

AP Cybersecurity

Application and Data Vulnerabilities and Attacks

Applications 应用程序 are the programs that run on computers, and **data** is what they process - both are prime targets. If files are stored **unencrypted**, anyone with access to the drive can read them. If a normal user is given **administrative** 管理员 privileges, an adversary who steals that account gains sweeping power.

The biggest application danger is bad **user input**. When a program does not check what a user types, an adversary can slip in commands - an **injection attack** 注入攻击. **Data validation** 数据验证 (checking input meets expected rules) is the defense. Key attacks:

- **SQL injection** 数据库注入 - inserting **SQL** commands into an input field to read or change a database.
- **Cross-site scripting (XSS)** 跨站脚本 - injecting malicious script into a website that runs in another user's browser.
- **Buffer overflow** 缓冲区溢出 - sending more data than a memory **buffer** 缓冲区 can hold, so it overflows into nearby memory and may run the adversary's code.
- **Directory traversal** 目录遍历 - using `../` sequences in a URL to reach files outside the intended folder, such as `/etc/passwd`.

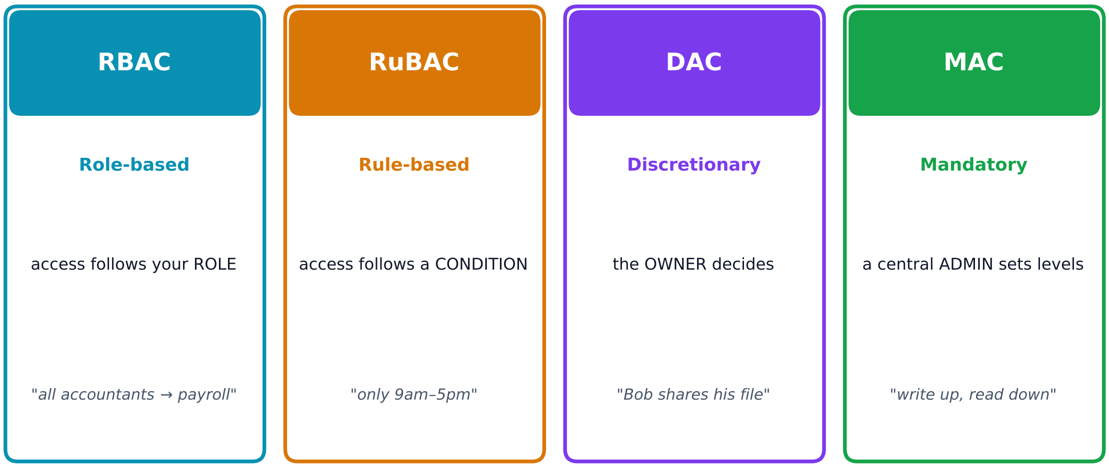
We rate data risk by sensitivity: unencrypted military plans are **high** risk; customer data with a weak key is **moderate**; low-value data with short keys is **low**.

Protecting Applications and Data: Managerial Controls and Access Controls

Data is classified by its **state** - **at rest** 静态数据 (stored on a drive), **in transit** 传输中数据 (moving between devices), and **in use** 使用中数据 (being processed). Laws require special care for **personally identifiable information (PII)** 个人身份信息, **protected health information (PHI)** 受保护健康信息, and **payment card information (PCI)** 支付卡信息.

Access control decides which **subjects** (users) may perform which **operations** on which **objects** (files). Four models:

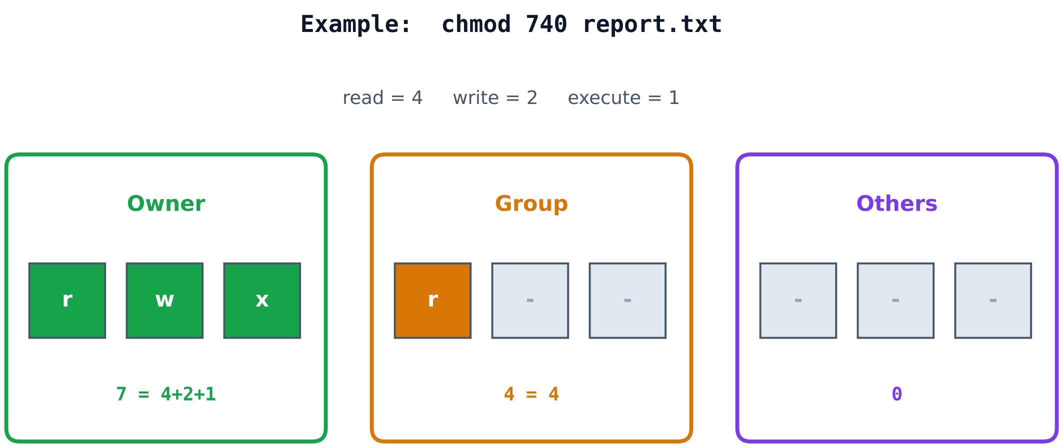
- **Role-based (RBAC)** 基于角色的访问控制 - access follows your **role** (all "accountants" reach the payroll software).
- **Rule-based (RuBAC)** 基于规则的访问控制 - access follows **conditions** (only during business hours), layered on another model.
- **Discretionary (DAC)** 自主访问控制 - the **owner** of a file decides who else may use it.
- **Mandatory (MAC)** 强制访问控制 - a central administrator sets strict levels; the **Bell-LaPadula** model summarises it as "write up, read down".



Four access-control models decide who reaches which object, and how

A guiding idea across all models is the **principle of least privilege** 最小权限原则 - give each entity exactly the access it needs and no more.

On a **Linux** system, each file has three permissions - **read (r)**, **write (w)**, **execute (x)** - for three groups: the **owner**, the **group**, and **others**. The `chmod` command sets them with numbers, adding 4 (read) + 2 (write) + 1 (execute). So `chmod 640` means owner read+write (6), group read (4), others nothing (0).



Linux file permissions: read/write/execute for owner, group, and others

Worked example. A principal wants only herself to read *and* edit a file, her staff group to read it, and no one else to touch it. Read+write = 4+2 = **6** for the owner, read = **4** for the group, nothing = **0** for others, giving `chmod 640 file`. The listing then shows `-rw-r-----`. To also let the owner run the file as a program you would add execute (7 = 4+2+1), giving `chmod 740`.

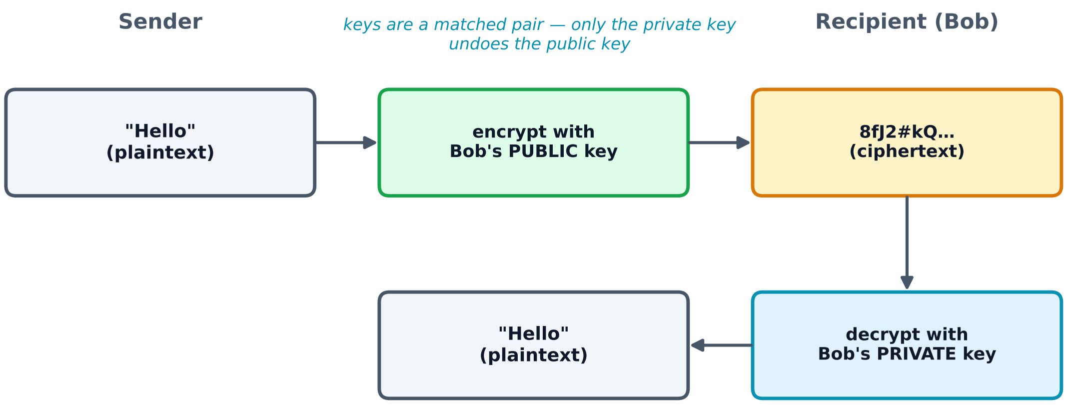
Protecting Stored Data with Cryptography

Cryptography 密码学 hides information. An **encryption** algorithm combines the **plaintext** 明文 with a **key** 密钥 to produce **ciphertext** 密文; **decryption** reverses it. The **keyspace** 密钥空间 is the number of possible keys - the bigger it is, the longer an adversary needs to guess. An **n-bit** key has a keyspace of 2^n.

Symmetric encryption 对称加密 uses the **same key** to encrypt and decrypt. The standard is **AES** 高级加密标准, a **block cipher** 分组密码 that works on 128-bit blocks and secures Wi-Fi, browsing, and stored files. Because both sides need the same secret key, sharing that key safely is the challenge.

Asymmetric Cryptography

Asymmetric encryption 非对称加密 solves the key-sharing problem with a **key pair** 密钥对 - a **public key** 公钥 anyone may see and a **private key** 私钥 kept secret. The keys are mathematical inverses: whatever one locks, only the other unlocks. To send you a secret, I encrypt with **your public key**, and only **your private key** can decrypt it - so we never had to share a secret in advance.



Asymmetric encryption: encrypt with the public key, decrypt with the private key

Longer keys mean larger keyspaces and more security, but slower encryption. Common asymmetric algorithms are **RSA** and **elliptic curve cryptography (ECC)** 椭圆曲线密码学, used in digital signatures and certificates. Remember: you can only compare key lengths **within the same algorithm** - an RSA 4096-bit key is not directly comparable to an AES 256-bit key.

Protecting Applications

Two design principles keep applications safe from the start. **Secure by design** 安全设计 builds security into every phase of development, not as an afterthought. **Secure by default** 默认安全 means the product ships with its security features already **enabled** - safe straight out of the box.

The key defense against injection attacks is **input sanitization** 输入清理. Special **control characters** 控制字符 - the single quote, double quote, and semicolon - can be used to manipulate a system, so a good program removes or rejects them before processing. Sanitization protects against SQL injection, XSS, and directory-traversal attacks alike.

Detecting Attacks on Data and Applications

To detect data attacks, systems perform **accounting** 审计记录 - logging who accessed what and when. A clever trick is a **honeypot** 蜜罐 - a fake file that looks valuable; since no one has a real reason to open it, any access is a clear sign of an attack. **Cryptographic hashes** also help: re-hash a file and compare - if the digest changed, the file was altered.

Choosing detective controls means weighing **cost** (honeypots are cheap; a **data loss prevention (DLP)** 数据泄露防护 service is powerful but pricey) against the sensitivity of the data. To read a specific attack from logs, look for its signature: SQL injection shows OR 1=1 and --; XSS shows <script> tags; directory traversal shows ../ sequences; a buffer overflow shows unusually long input strings.

Exam tips

- Match each application attack to its **evidence in a log**: OR 1=1 / -- = **SQL injection**; <script> = **XSS**; ../ = **directory traversal**; very long input = **buffer overflow**.
- Learn the four access-control models by their **decider**: RBAC = your role, RuBAC = a condition, DAC = the file's owner, MAC = a central admin. **Least privilege** underlies them all.
- Read Linux permissions by adding **4+2+1** per group - chmod 750 = owner rwx (7), group r-x (5), others none (0). Practice converting both ways.
- **Symmetric** = one shared key (fast, AES); **asymmetric** = a public/private key pair (solves key sharing, RSA/ECC). Encrypt with the **recipient's public key**.
- **Input sanitization** is the single best answer for preventing injection attacks; a **honeypot** is the classic cheap detective control.