PAM
(Pluggable Authentication Modules)

Motivation

- Users
  - Unification of authentication mechanisms for different applications
- Manufacturers
  - Authenticated access to services independent of authentication mechanisms
- Administrators
  - Easy orchestration of authentication mechanisms different services requiring client authentication
  - Flexibility to configure specific authentication mechanisms for each host
- Manufacturers and Administrators
  - Flexible and modular approach for integrating novel authentication mechanisms

PAM: features

- Independent authentication protocols / mechanisms
  - Linux password, S/Key, smartcards, biometrics, etc.
  - One module per protocol / mechanism
- Orchestration of protocols / mechanisms
  - Alone or combined
  - AND and OR combinations
  - Application-independent
- Several interface approaches
  - Input from text consoles of graphical windows
  - Access to special devices (smart-cards, biometric readers, etc.)

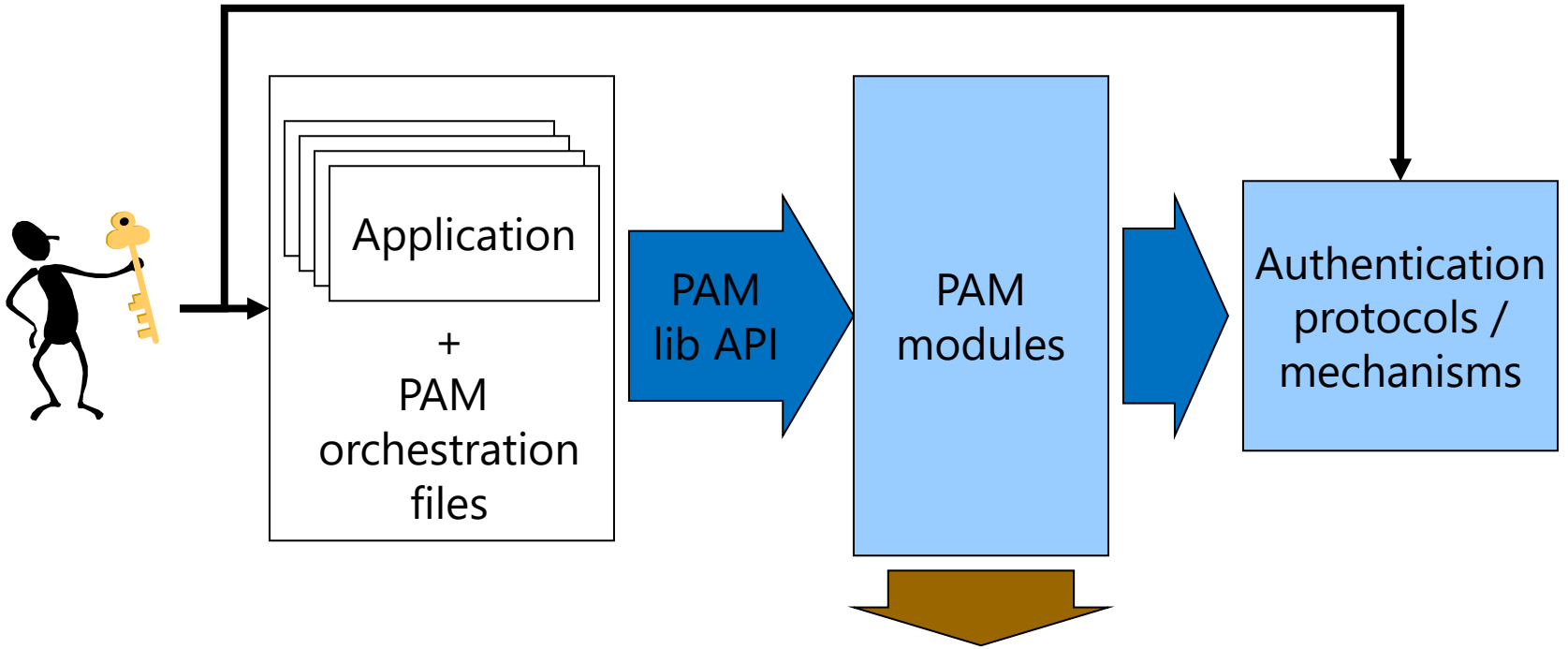
PAM: features

- Modular and extensible architecture
  - Dynamic loading of required modules
  - Handling of several actions besides authentication
    - Password management
    - Accounting management
    - Session management
- Default orchestration per host
  - Defined by the administrator
    - Username/password, biometrics, smart-cards, etc.
- Application-specific orchestrations
  - Each application can use a unique orchestration

Classic Unix authentication

- Requested input: username + password
- Validation
  - Active account for username
    - Entry with the username in the /etc/passwd file
  - Transformed password for that username
    - Entry with the username in the /etc/shadow file
  - Transformation of the provided password with the function and the salt used for that username
  - Comparison with the stored transformation
- Obtained credentials
  - UID + GID [+ list of secondary GIDs]
  - New process descriptor (login shell)

PAM: Architecture



PAM: Actions

- Authentication (auth)
  - Identity verification
- Account Management (account)
  - Enforcement of access policies based on account properties
- Password Management (password)
  - Management of authentication credentials
- Session Management (session)
  - Verification of operational parameters
  - Setup of session parameters
    - max memory, max file descriptions, graphical interface configuration, ...

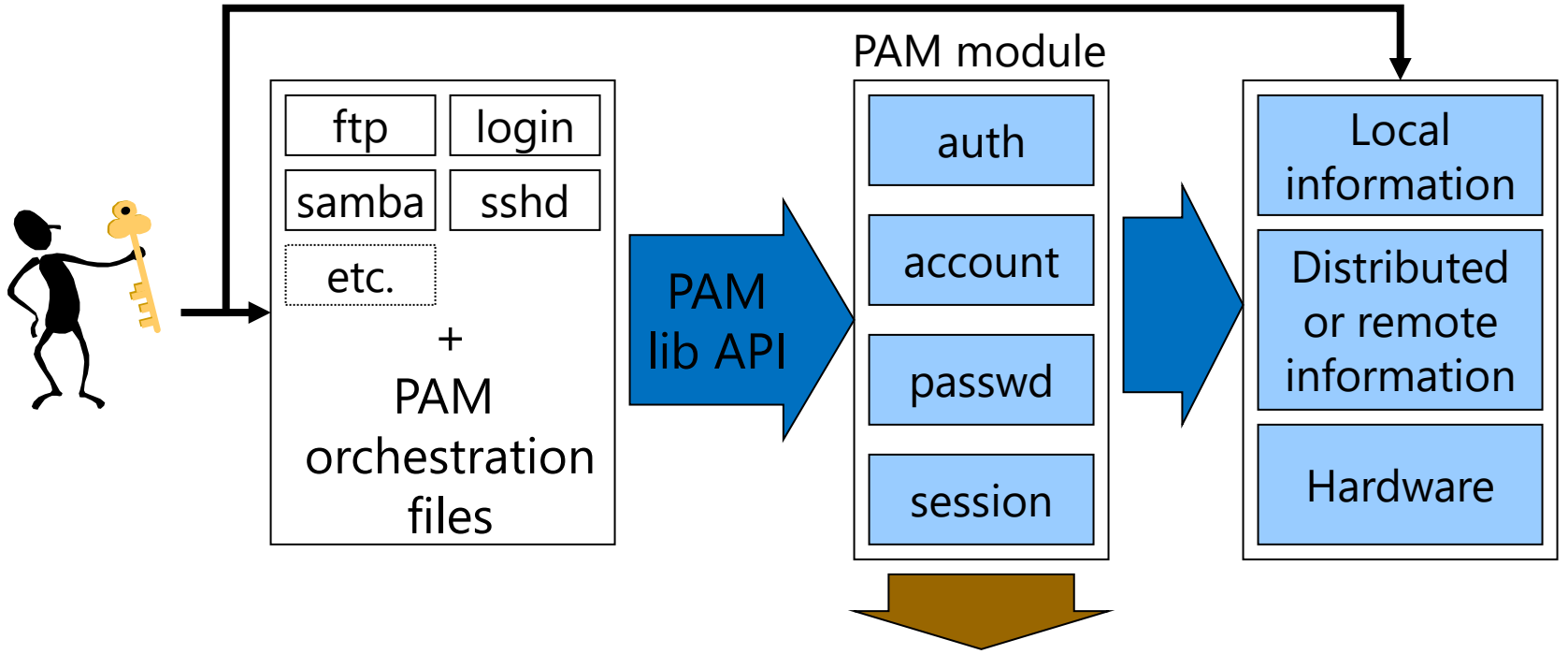
PAM: Modules

- Dynamically loaded (*shared libraries*)
  - /lib/security/pam_*.so
  - /lib/x86_64-linux-gnu/security/pam_*.so
- Standard API
  - Functions provided by the modules that are used
    - C interfaces
    - Python wrapper exists
  - Decision provided on returned code
    - PAM_SUCCESS
    - PAM_AUTH_ERR, PAM_AUTHINFO_UNAVAIL, etc…
  - Not all functions need to be implemented
    - A module does not need to implement all 4 actions

PAM: orchestration files

- Typically, one per PAM client application
  - e.g. /etc/pam.d/ftp or /etc/pam.d/ssh
  - Can use shared files: /etc/pam.d/common-auth
- Specify how the actions should be applied
  - Their mechanisms (modules)
  - Their parameters
  - Their termination, with or without success
- Each module uses a particular set of resources
  - Local files
    - /etc/passwd, /etc/shadow, /etc/groups, etc.
  - Distributed information or located in remote servers
    - NIS, Kerberos, LDAP, etc.

PAM: Detailed Architecture



Setup of identification, authentication and authorization information

PAM APIs:
PAM lib (used by applications)

- Start/end of the PAM lib
  pam_start(service, user name, callback, &pam_handle)
  pam_end(pam_handle, status)
- Module specific data
  pam_get_data()
  pam_set_data()

  pam_get_item()
  pam_set_item()
- "auth" action
  pam_authenticate(pam_handle, flags)
  pam_setcred(pam_handle, flags)
- "account" action
  pam_acct_mgmt(pam_handle, flags)
- "passwd" action
  pam_chauthtok(pam_handle, flags)
- "session" action
  pam_open_session(pam_handle, flags)
  pam_close_session(pam_handle, flags)

Orchestration of PAM actions

- Sequence of module invocations per action
  - By default, modules are executed sequentially
  - Each module has its own parameters and calling semantic
    - Required, requisite, sufficient, optional
    - […]
  - Execution proceeds until the end, or failure
    - To better hide the source of a failure, module execution can either abort immediately or delay the failure upon executing the entire sequence
  - Applications can recover from failures

PAM APIs:
PAM modules' API

- "auth" action
  pam_sm_authenticate(pam_handle, flags)
  pam_sm_setcred(pam_handle, flags)
- "account" action
  pam_sm_acct_mgmt(pam_handle, flags)
- "passwd" action
  pam_sm_chauthtok(pam_handle, flags)
- "session" action
  pam_sm_open_session(pam_handle, flags)
  pam_sm_close_session(pam_handle, flags)

PAM: Module invocation

- Syntax: action control module [parameters]

- Control is specified for each action and module
  requisite
  required
  sufficient
  optional

  [success=ok/number default=ignore/die/bad …]

PAM: Module invocation

- required: The module result must be successful for authentication to continue.
  - If the test fails at this point, the user is not notified until the results of all module tests that reference that interface are complete.
- requisite: The module result must be successful for authentication to continue.
  - However, if a test fails at this point, the user is notified immediately with a message reflecting the first failed required or requisite module test.
- sufficient: The module result is ignored if it fails.
  - If the result of a module flagged sufficient is successful and no previous modules flagged required have failed, then no other results are required and the user is authenticated

PAM: Module invocation

- optional: The module result is ignored.
  - A module flagged as optional only becomes necessary for successful authentication when no other modules reference the interface.

- include: Unlike the other controls, this does not relate to how the module result is handled.
  - This flag pulls in all lines in the configuration file which match the given parameter and appends them as an argument to the module.

Configuration files: /etc/pam.d/login

```
auth optional pam_faildelay.so delay=3000000
auth [success=ok new_authtok_reqd=ok ignore=ignore user_unknown=bad default=die] pam_securetty.so
auth requisite pam_nologin.so

session [success=ok ignore=ignore module_unknown=ignore default=bad] pam_selinux.so close
session required pam_loginuid.so
session [success=ok ignore=ignore module_unknown=ignore default=bad] pam_selinux.so open
session required pam_env.so readenv=1
session required pam_env.so readenv=1 envfile=/etc/default/locale

@include common-auth
auth optional pam_group.so

session required pam_limits.so
session optional pam_lastlog.so
session optional pam_motd.so motd=/run/motd.dynamic
session optional pam_motd.so noupdate
session optional pam_mail.so standard
session optional pam_keyinit.so force revoke

@include common-account
@include common-session
@include common-password
```

PAM orchestration files: Advanced decision syntax

- [value=action value=action ...]
- Actions:
  - ignore: take no decision
  - bad: continue, but the final decision will be a failure
  - die: terminate immediately with failure
  - ok: continue, so far the decision is success
  - done: terminate immediately with success
  - reset: clear the entire state and continue
  - N (unsigned integer): same as ok + jump over N lines

PAM orchestration files: Advanced decision syntax

- Values (return codes)
  - *success*
  - *open_err*
  - *symbol_err*
  - *service_err*
  - *system_err*
  - *buf_err*
  - *perm_denied*
  - *auth_err*
  - *cred_insufficient*
  - *authinfo_unavail*
  - *user_unknown*
  - *maxtries*
  - *new_authtok_reqd*
  - *acct_expired*
  - *session_err*
  - *cred_unavail*
  - *cred_expired*
  - *cred_err*
  - *no_module_data*
  - *conv_err*
  - *authtok_err*
  - *authtok_recover_err*
  - *authtok_lock_busy*
  - *authtok_disable_aging*
  - *try_again*
  - *ignore*
  - *abort*
  - *authtok_expired*
  - *module_unknown*
  - *bad_item*
  - *conv_again*
  - *incomplete*
  - *default*
    - *Any not specified*

PAM orchestration files: Simplified decision syntax

- High-level decisions definitions
  - requisite
    - [success=ok new_authtok_reqd=ok ignore=ignore default=die]
  - required
    - [success=ok new_authtok_reqd=ok ignore=ignore default=bad]
  - sufficient
    - [success=done new_authtok_reqd=ok default=ignore]
  - optional
    - [success=ok new_authtok_reqd=ok default=ignore]

Scenario 2 – LDAP auth with local backoff

```
auth     required    /lib/security/pam_env.so
auth     sufficient  /lib/security/pam_unix.so likeauth nullok
auth     sufficient  /lib/security/pam_ldap.so use_first_pass
auth     required    /lib/security/pam_deny.so

account  required    /lib/security/pam_unix.so
account  [default=bad success=ok user_unknown=ignore] pam_ldap.so


password required    /lib/security/pam_cracklib.so retry=3
password sufficient  /lib/security/pam_unix.so nullok use_authtok md5 shadow
password sufficient  /lib/security/pam_ldap.so
password required    /lib/security/pam_deny.so

session  required    /lib/security/pam_limits.so
session  required    /lib/security/pam_unix.so
session  optional    /lib/security/pam_ldap.so
```

Try local accounts (for offline admin) and then LDAP

Allow changing the password of both local and remote accounts

Scenario 1 – Local authentication

```
auth       required     /lib/security/pam_env.so
auth       sufficient   /lib/security/pam_unix.so likeauth nullok
auth       required     /lib/security/pam_deny.so

account    required     /lib/security/pam_unix.so

password   required     /lib/security/pam_cracklib.so retry=3
password   sufficient   /lib/security/pam_unix.so nullok use_authtok md5 shadow
password   required     /lib/security/pam_deny.so

session    required     /lib/security/pam_limits.so
session    required     /lib/security/pam_unix.so
```

Use system files

Prevent using weak passwords

Use md5 to store passwords in shadow

Scenario 2 – LDAP auth with local backoff

- LDAP server provides directory with users
  - Identifiers, shell, email, name
  - Group membership

- saslauthd: provides interface with remote directory
  - User identifiers and atributes
  - Group membership

Scenario 2 – LDAP auth with local backoff

```
ldap_servers: ldaps://dc1.DOMAIN.TLD
ldap_search_base: dc=DOMAIN,dc=TLD
ldap_bind_dn: cn=admin,ou=host,dc=DOMAIN,dc=TLD
ldap_bind_pw: Sup3rS3cr3TP4ssw0Rd
ldap_filter: (uid=%U)
ldap_scope: sub
#ldap_group_attr: memberUid
#ldap_group_match_method: filter
#ldap_group_filter: (memberUid=%u)
#ldap_group_search_base: ou=group,dc=DOMAIN,dc=TLD
#ldap_size_limit: 0
ldap_tls_check_peer: yes
ldap_tls_cacert_file: /etc/ldap/certs.txt
ldap_tls_cacert_dir: /etc/ssl/certs/
ldap_time_limit: 15
ldap_timeout: 15
ldap_version: 3
```

Specificies where server can be found

bind_dn is a system account to query the LDAP

Group membership mapping can be set

Scenario 2 – LDAP auth with local backoff

```
auth     required    /lib/security/pam_env.so
auth     sufficient  /lib/security/pam_unix.so likeauth nullok
auth     sufficient  /lib/security/pam_ldap.so use_first_pass
auth     required    /lib/security/pam_deny.so

account  required    /lib/security/pam_unix.so
account  [default=bad success=ok user_unknown=ignore] pam_ldap.so


password required    /lib/security/pam_cracklib.so retry=3
password sufficient  /lib/security/pam_unix.so nullok use_authtok md5 shadow
password sufficient  /lib/security/pam_ldap.so
password required    /lib/security/pam_deny.so

session  required    /lib/security/pam_limits.so
session  required    /lib/security/pam_unix.so
session  optional    /lib/security/pam_ldap.so
```

Try local accounts (for offline admin) and then LDAP

Allow changing the password of both local and remote accounts

Scenario 3 – MS AD auth with local backoff

- MS AD server provides directory with users
  - Identifiers, shell, email, name
  - Group membership
- Machine must be enrolled into domain
  - Requires login using admin credentials
- sssd: System Security Services Daemon
  - Provides and caches information from remote AD system

Scenario 3 – MS AD auth with local backoff

```
[sssd]
domains = DOMAIN.TLD
config_file_version = 2
services = nss, pam
default_domain_suffix = DOMAIN.TLD

[domain/DOMAIN.TLD]
default_shell = /bin/bash
krb5_store_password_if_offline = True
cache_credentials = True
krb5_realm = DOMAIN.TLD
realmd_tags = manages-system joined-with-adcli
id_provider = ad
fallback_homedir = /home/%u@%d
ad_domain = DOMAIN.TLD
use_fully_qualified_names = True
ldap_id_mapping = True
access_provider = simple
simple_allow_groups = group-admins
```

Typical SSSD configuration at /etc/sssd/sssd.conf

Specified Domain and Kerberos5 configurations

Kerberos is the effective authentication protocol issuing authnz tickets

Supports MFA and HSM

Scenario 3 – MS AD auth with local backoff

```
auth            [success=2 default=ignore]      pam_unix.so nullok
auth            [success=1 default=ignore]      pam_sss.so use_first_pass
auth            requisite                       pam_deny.so
auth            required                        pam_permit.so
auth            optional                        pam_cap.so

account [success=1 default=ignore]                      pam_unix.so
account [default=bad success=ok user_unknown=ignore]    pam_sss.so
account required                                        pam_permit.so

password        requisite                       pam_pwquality.so retry=3
password        [success=2 default=ignore]      pam_unix.so obscure use_authtok try_first_pass yescrypt
password        sufficient                      pam_sss.so use_authtok
password        requisite                       pam_deny.so
password        required                        pam_permit.so

session         required                      pam_unix.so
session         optional                      pam_sss.so
session         optional                      pam_systemd.so
session         optional                      pam_mkhomedir.so
session         required                      pam_permit.so
```

Try local accounts (for offline admin) and then AD
Deny the rest
Clear errors
Set inheritable capabilities

Set Session Settings from local conf, AD
Register session in systemd
Create home directory