

CONCISO.

Unlocking the Power of Keycloak

Best Practices for Extension Development

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Keycloak Extensions



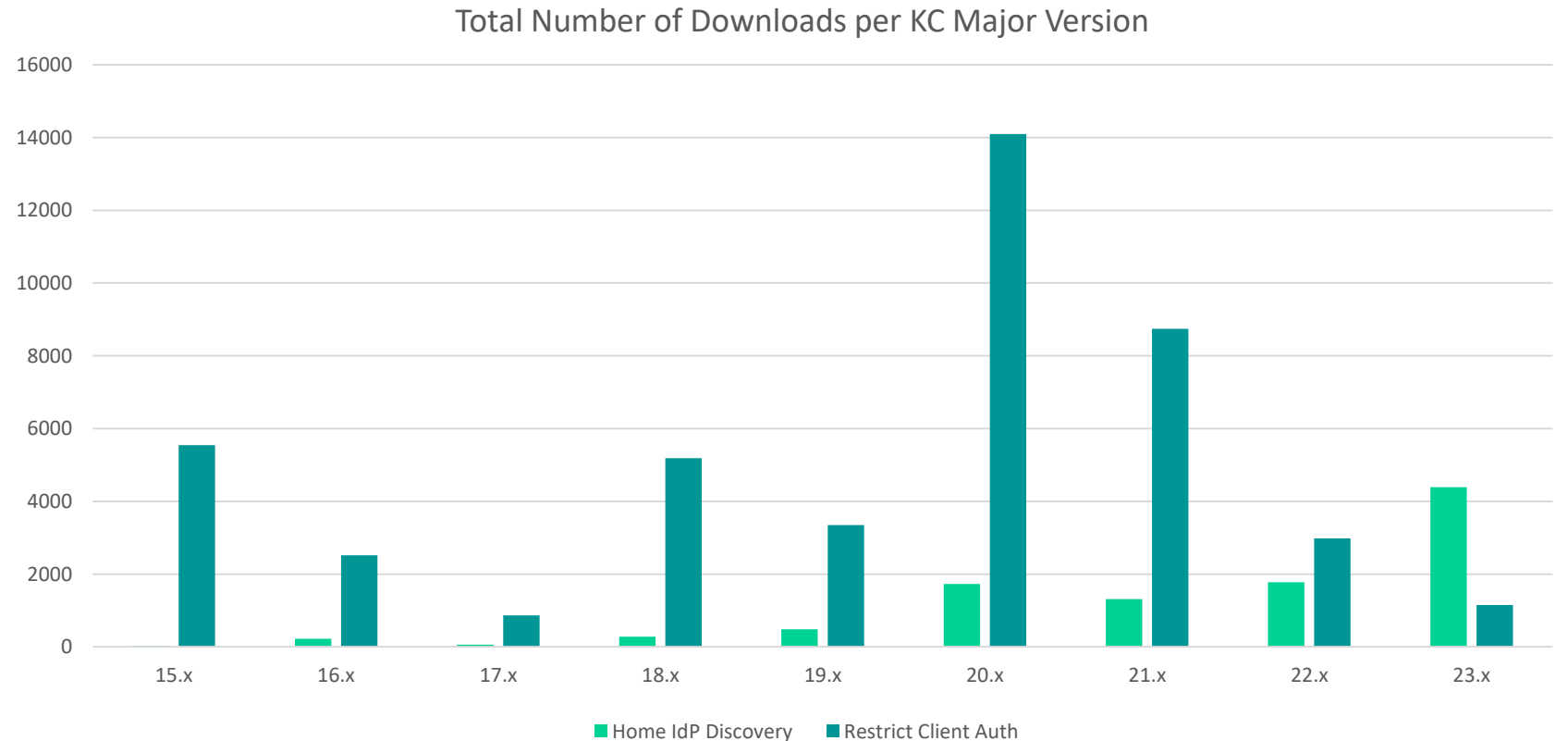
Home IdP Discovery

Restrict Client Auth



Adoption

- SovereignCloudStack
- Phase Two
- Several larger enterprises



What CONCISO. builds for customers

- Custom Themes and Templates
- Authenticators
- User Storage Providers
- Protocol / IdP / LDAP Mappers
- Client Policies (Conditions and Executors)
- Required Actions
- Event Listeners
- Custom REST APIs
- Custom Domain Models / Entities

Keycloak Extensions - Overview



What are Keycloak Extensions?

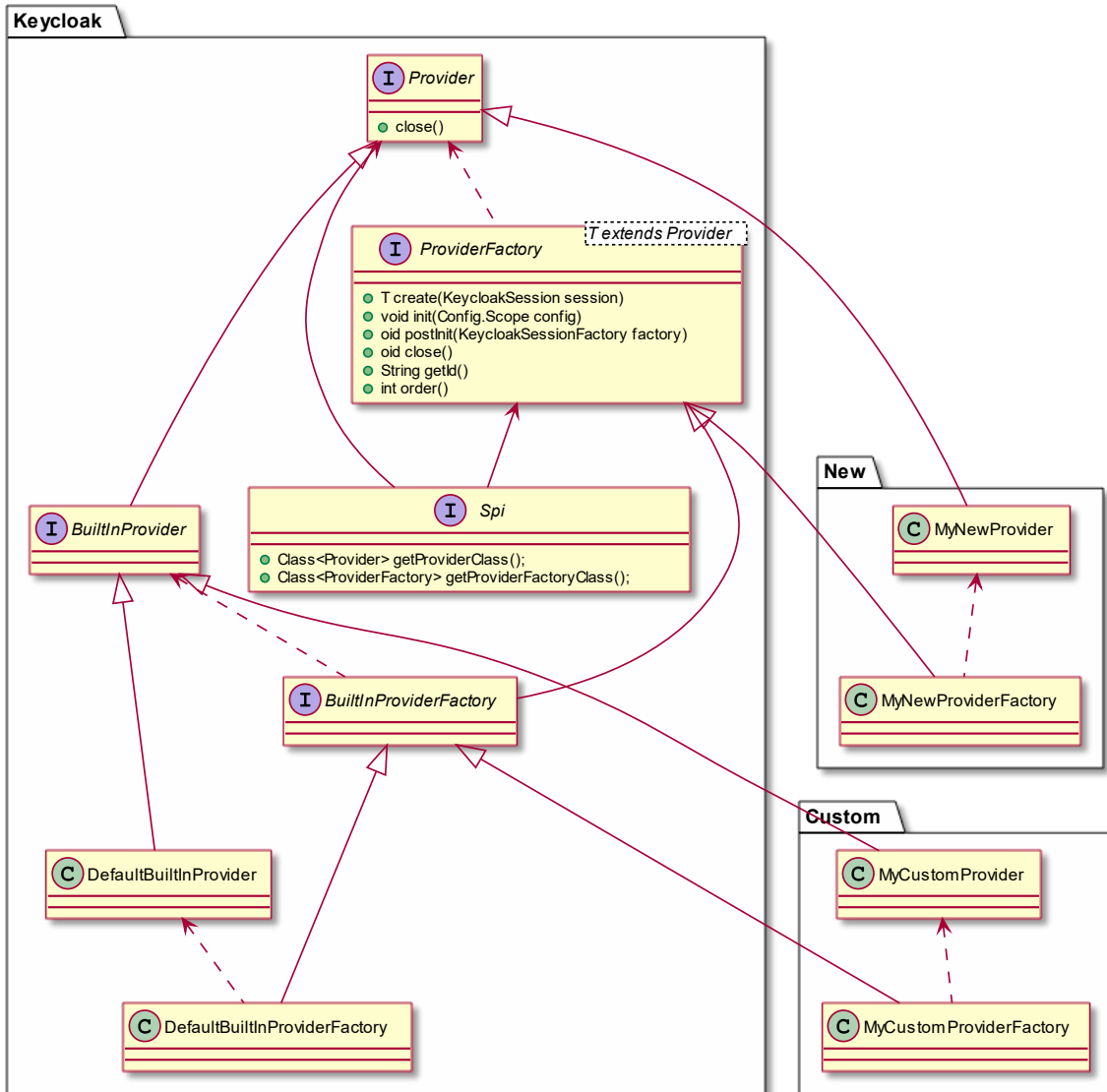
Keycloak extensions are designed to extend the core functionalities of Keycloak to meet specific, custom requirements that aren't covered by the default installation.

The screenshot displays the Keycloak Admin Console interface. The left sidebar is dark-themed and contains a navigation menu with options: Manage, Clients, Client scopes, Realm roles, Users, Groups, Sessions, Events, Configure, Realm settings, Authentication, Identity providers, and User federation. The main content area is titled 'master realm' and features two tabs: 'Server info' and 'Provider info'. A search bar with a magnifying glass icon and a right-pointing arrow is located below the tabs. Below the search bar is a table with two columns: 'SPI' and 'Add providers'. The table lists various SPIs and their corresponding providers.

SPI	Add providers
account-resource	default
actionTokenHandler	verify-email execute-actions reset-credentials idp-verify-account-via-email update-email
admin-realm-restapi-extension	clear-realm-cache clear-user-cache ldap-server-capabilities testLDAPConnection ui-ext user-storage clear-keys-cache
authenticationSessions	infinispan
authenticator	auth-cookie reset-credentials-choose-user direct-grant-validate-password webauthn-authenticator auth-spnego direct-grant-auth-x509-username reset-password auth-password-form

Some UML?!

Keycloak Service Provider - Class Diagram



Additional interfaces

ConfiguredProvider

Providers can be configured via Keycloak UI

ServerInfoAwareProviderFactory

ProviderFactories can display additional information in provider info page

How to write and activate an extension?



Code the provider factory (Java class)

Code the provider (Java class)

Register the provider in the services manifest (Java SE Service Provider)

Package a JAR file

Copy JAR file to providers folder of your Keycloak instance(s) / image

```
FROM registry.access.redhat.com/ubi9 AS ubi-micro-build

ARG HIDPD_VERSION=23.0.0

RUN mkdir -p /mnt/rootfs/extensions
RUN dnf install --installroot /mnt/rootfs curl --releasever 9 \
  --setopt install_weak_deps=false --nodocs -y && \
  dnf --installroot /mnt/rootfs clean all && \
  rpm --root /mnt/rootfs -e --nodeps setup

RUN curl -L -s -o /extensions/keycloak-home-idp-discovery.jar \
  https://github.com/sventorben/keycloak-home-idp-
  discovery/releases/download/v$HIDPD_VERSION/keycloak-home-idp-
  discovery.jar

FROM quay.io/keycloak/keycloak:23.0.6

COPY --from=ubi-micro-build --chown=keycloak:keycloak /extensions/
/opt/keycloak/providers/
```

Extension versioning



The most asked question?

Is version A.B.C of this extension compatible with Keycloak version X.Y.Z?

Tip: Align the major version of your extension with Keycloak's major version.

Extension version: **23.0.2**

Compatible KC versions: **23.0.0**, **23.0.1**, **23.0.2**, **23.0.3** ...

Second most asked question?

Them: I have upgraded from Keycloak version X to **Y**. Your extension is not working anymore.

Me: Have you upgraded to latest version of my extension: **Y.a.b**?

Them: Yes, of course ...

Turns out they didn't!

Tip: Make your extension's version visible on Keycloak's UI and API!

The screenshot shows the Keycloak Admin Console interface. On the left is a dark sidebar with navigation options: Manage, Clients, Client scopes, Realm roles, Users, Groups, Sessions, Events, Configure, Realm settings, Authentication, Identity providers, and User federation. The main content area is titled 'master realm' and has tabs for 'Server info' and 'Provider info'. A search bar contains the text 'authenticator'. Below the search bar is a table with two columns: 'SPI' and 'Add providers'. The 'authenticator' SPI is listed in the first column. The 'Add providers' column lists several providers, with 'home-idp-discovery' highlighted by a red box. Below 'home-idp-discovery' is a 'Show less' link. At the bottom of the red box, the 'Version' is listed as '23.0.1-SNAPSHOT'. Other providers listed include auth-cookie, reset-credentials-choose-user, direct-grant-validate-password, webauthn-authenticator, auth-spnego, direct-grant-auth-x509-username, reset-password, auth-password-form, docker-http-basic-authenticator, allow-access-authenticator, idp-username-password-form, auth-x509-client-username-form, idp-auto-link, and idp-email-verification.

SPI	Add providers
authenticator	auth-cookie reset-credentials-choose-user direct-grant-validate-password webauthn-authenticator auth-spnego direct-grant-auth-x509-username reset-password auth-password-form docker-http-basic-authenticator allow-access-authenticator home-idp-discovery ▼ Show less Version 23.0.1-SNAPSHOT idp-username-password-form auth-x509-client-username-form idp-auto-link idp-email-verification

Tip: Make your extension's version accessible via Keycloak's UI and API!

Implement the **ServiceInfoAwareProvider** interface!

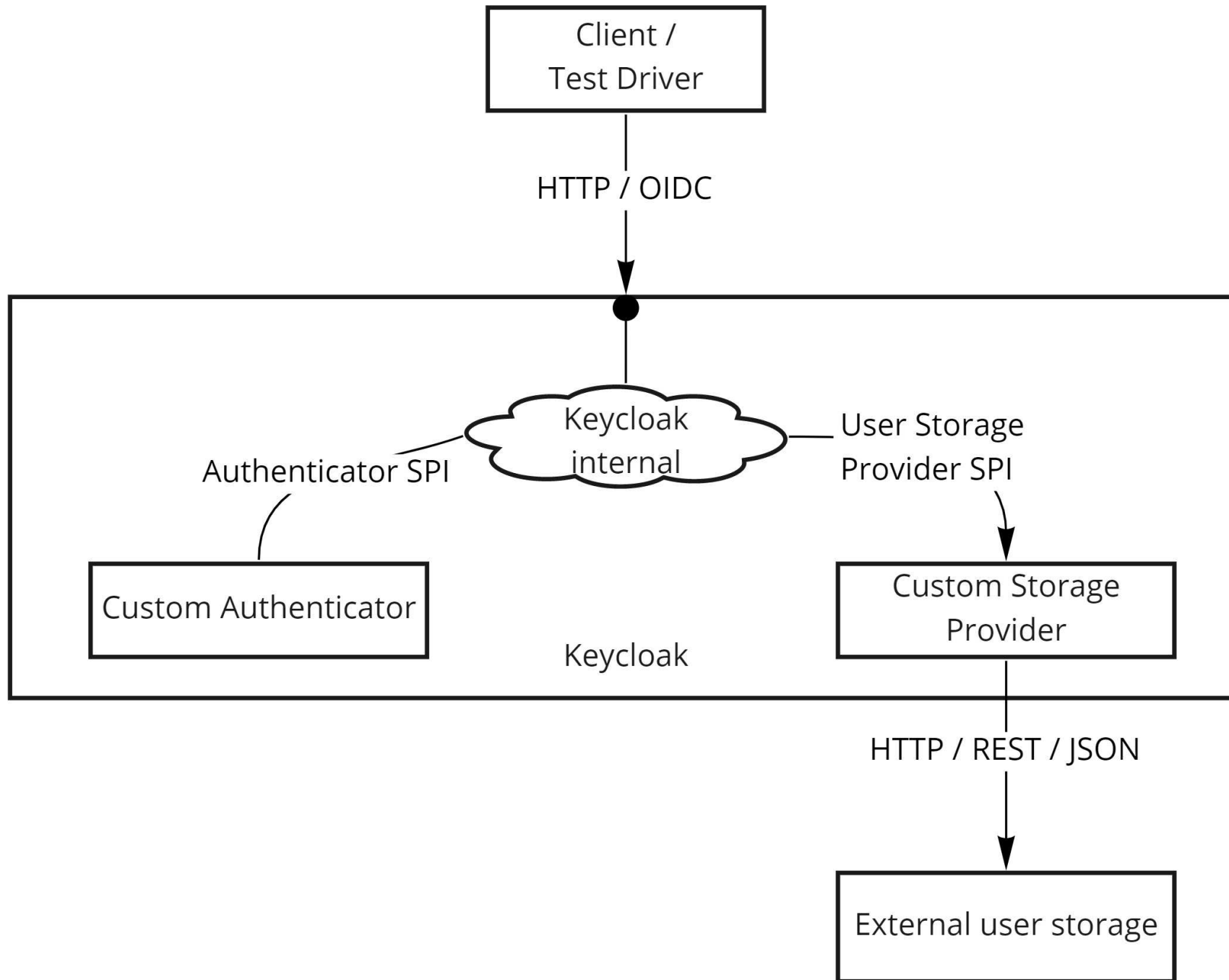
```
@Override
public Map<String, String> getOperationalInfo() {
    String version = getClass().getPackage().getImplementationVersion();
    if (version == null) {
        version = "dev-snapshot";
    }
    return Map.of("Version", version);
}
```

You may also want to add provider factory configuration values.

```
<plugin>
  <groupId>org.apache.maven.plugins</groupId>
  <artifactId>maven-jar-plugin</artifactId>
  <version>3.3.0</version>
  <configuration>
    <archive>
      <manifest>
        <addDefaultImplementationEntries>
          true
        </addDefaultImplementationEntries>
      </manifest>
    </archive>
  </configuration>
</plugin>
```


The Safety Net

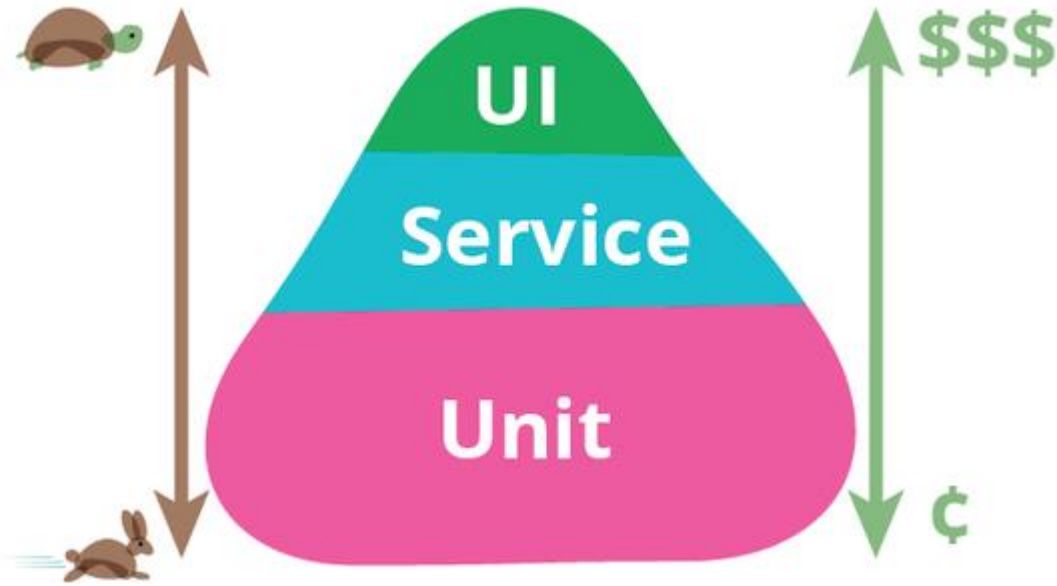




KeycloakSession – the main integration point

```
public interface KeycloakSession extends AutoCloseable {
    KeycloakContext getContext();
    KeycloakTransactionManager getTransactionManager();
    KeycloakSessionFactory getKeycloakSessionFactory();
    RealmProvider realms();
    ClientProvider clients();
    ClientScopeProvider clientScopes();
    GroupProvider groups();
    RoleProvider roles();
    UserSessionProvider sessions();
    UserLoginFailureProvider loginFailures();
    AuthenticationSessionProvider authenticationSessions();
    UserProvider users();
    KeyManager keys();
    ThemeManager theme();
    TokenManager tokens();
    ClientPolicyManager clientPolicy();
    <T extends Provider> T getProvider(Class<T> clazz);
    //...
}
```

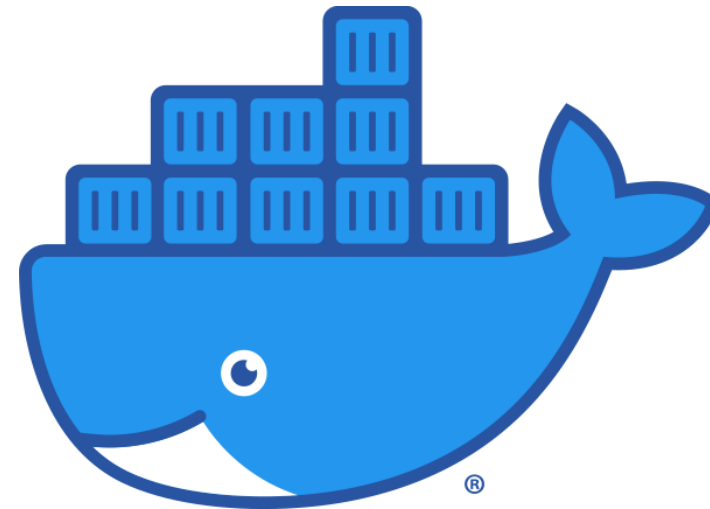
Testpyramid



Source: Fowler - <https://martinfowler.com/bliki/TestPyramid.html>



Source: Wikipedia / Lawrence Livermore National Laboratory



Speed

← Build and test

✓ chore(deps-dev): bump version.testcontainers from 1.19.4 to 1.19.5 #523

Re-run jobs

Summary

Jobs

- ✓ build
- ✓ compatibility (22.0.5, false)
- ✓ compatibility (23.0.0, false)
- ✓ compatibility (23.0.1, false)
- ✓ compatibility (23.0.2, false)
- ✓ compatibility (23.0.3, false)
- ✓ compatibility (23.0.4, false)
- ✓ compatibility (23.0.5, false)
- ✓ compatibility (23.0.6, false)
- ✓ **compatibility (latest, false)**
- ✗ compatibility (nightly, true)

compatibility (latest, false)

succeeded 5 days ago in 3m 14s

Beta

Give feedback

Search logs

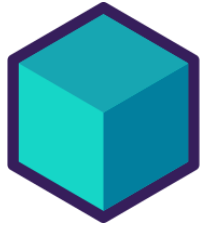


- > ✓ Set up job
- > ✓ Run actions/checkout@v4
- > ✓ Set up JDK 17
- > ✓ Compatibility tests
- > ✓ Post Set up JDK 17
- > ✓ Post Run actions/checkout@v4
- > ✓ Complete job

It's that slow! (3m 10s)
Including build, integration
tests, artifact release!

0s
0s
1s
3m 10s
0s
0s
0s

Testcontainers to the rescue



Testcontainers

“Testcontainers is a testing library that provides easy and lightweight APIs for bootstrapping integration tests with real services wrapped in Docker containers.

Using Testcontainers, you can write tests talking to the same type of services you use in production without mocks or in-memory services.”

Keycloak Testcontainer by Niko Köbler

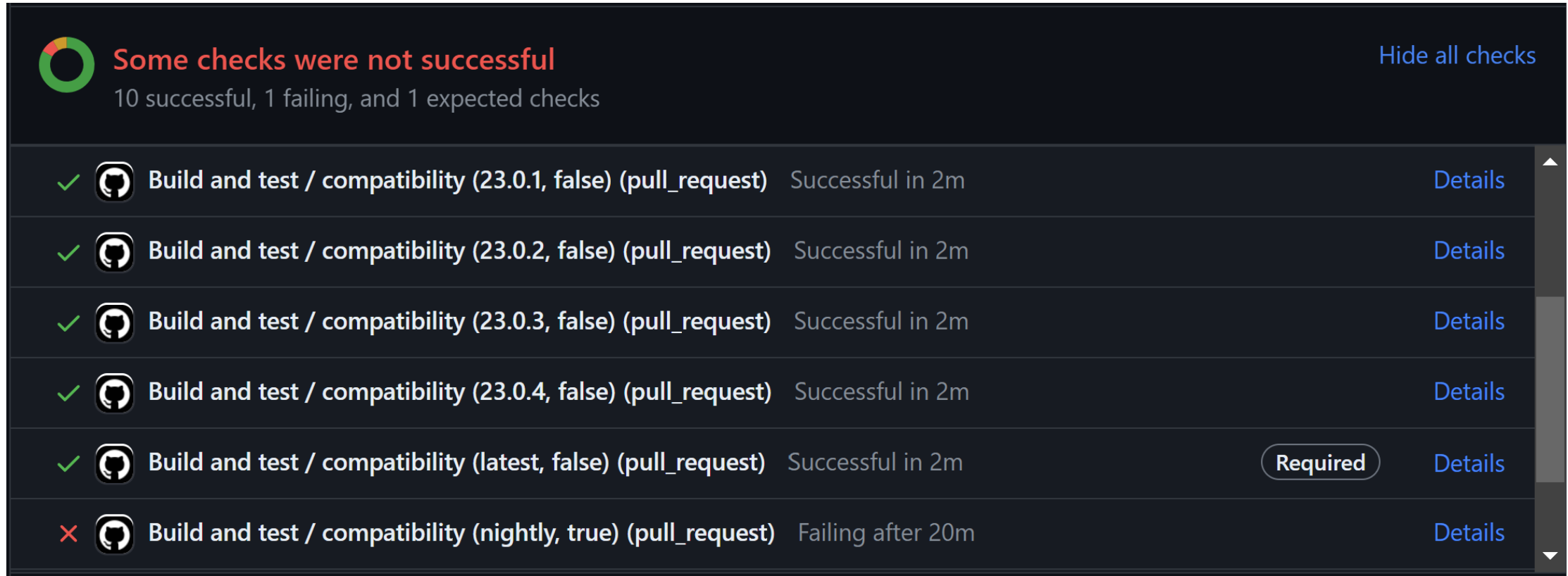


```
KeycloakContainer kc = new KeycloakContainer(fullImage)
    .withImagePullPolicy(pullPolicy);

if (useLibrary) {
    kc = kc.withProviderLibsFrom(List.of(new File("target/keycloak-restrict-client-auth.jar")));
} else {
    kc = kc.withProviderClassesFrom("target/classes");
}

kc.getKeycloakAdminClient()
    .realm("test-realm")
    .users()
    .get("139020a3-4459-43b1-a92f-d90e5cf093a1")
    .logout();
```

Tip: Test all changes (features, fixes, dependency updates, ...) with supported Keycloak versions



The screenshot displays a summary of CI/CD pipeline checks. At the top, a green progress indicator shows that 10 checks were successful, 1 failed, and 1 was expected. The failed check is highlighted in red. Below the summary, a list of checks is shown, each with a status icon (checkmark or cross), a GitHub icon, a description of the check, the result, and a 'Details' link. The failed check is 'Build and test / compatibility (nightly, true) (pull_request)' which failed after 20 minutes.

Some checks were not successful [Hide all checks](#)
10 successful, 1 failing, and 1 expected checks

✓		Build and test / compatibility (23.0.1, false) (pull_request)	Successful in 2m	Details
✓		Build and test / compatibility (23.0.2, false) (pull_request)	Successful in 2m	Details
✓		Build and test / compatibility (23.0.3, false) (pull_request)	Successful in 2m	Details
✓		Build and test / compatibility (23.0.4, false) (pull_request)	Successful in 2m	Details
✓		Build and test / compatibility (latest, false) (pull_request)	Successful in 2m	Required Details
✗		Build and test / compatibility (nightly, true) (pull_request)	Failing after 20m	Details

Tip: Test all changes, new features, fixes with supported Keycloak versions

```
compatibility:  
  runs-on: ubuntu-latest  
  strategy:  
    fail-fast: false  
    matrix:  
      keycloak_version: [ 21.0.2, 21.1.2, 22.0.5, 23.0.0, 23.0.1, 23.0.2, 23.0.3, 23.0.4, 23.0.5, latest ]  
      experimental: [false]  
      include:  
        - keycloak_version: nightly  
          experimental: true  
    continue-on-error: ${ matrix.experimental }  
  steps:  
    ...  
    - name: Compatibility tests  
      run: mvn -B -U clean test-compile failsafe:integration-test failsafe:verify --file pom.xml \  
        -Dkeycloak.version=${ matrix.keycloak_version }
```

Tip: Test all new Keycloak versions with all extension versions

		Keycloak					
		21.0.2	21.1.2	22.0.5	23.0.6	latest	nightly
Extension	21.3.0	ok	ok	fail	fail	fail	fail
	22.0.0	fail	fail	ok	ok	ok	fail
	22.1.0	fail	fail	ok	ok	ok	fail
	23.0.0	fail	fail	ok	ok	ok	fail

```
compatibility:
  runs-on: ubuntu-latest
  strategy:
    fail-fast: false
  matrix:
    keycloak_version: [ 21.0.2, 21.1.2, 22.0.5, 23.0.6, latest, nightly ]
    extension_version: [ 21.3.0, 22.0.0, 22.1.0, 23.0.0 ]
  steps:
    - uses: actions/checkout@v4
      with:
        ref: v${{ matrix.extension_version }}
    ...
    - name: Download extension
      run: curl -L -o target/keycloak-restrict-client-auth.jar https://github.com/sventorben/keycloak-restrict-client-auth/releases/download/v${{ matrix.extension_version }}/keycloak-restrict-client-auth.jar
    - name: Compatibility tests
      run: mvn -B -U clean test-compile failsafe:integration-test failsafe:verify --file pom.xml \
        -Dkeycloak.version=${{ matrix.keycloak_version }} -DuseLibrary=true
```

How to debug it?

```
version: '3'
services:
  keycloak:
    container_name: keycloak
    hostname: keycloak
    image: quay.io/keycloak/keycloak:23.0.6
    environment:
      KEYCLOAK_ADMIN: admin
      KEYCLOAK_ADMIN_PASSWORD: admin
      DEBUG_PORT: '*:8787'
      DEBUG: 'true'
    command: ['start-dev']
    ports:
      - 8080:8080
      - 8787:8787
```

Equivalent command line arguments for remote VM:

```
-agentlib:jdwp=transport=dt_socket,server=y,suspend=n,address=*:8787
```

Stability and backwards compatibility



Ensure Stability by Encapsulation

Wrap configuration models

```
final class HomelDpDiscoveryAuthenticator implements Authenticator {  
  
    @Override  
    public void authenticate(AuthenticationFlowContext authenticationFlowContext) {  
  
        var config = new HomelDpDiscoveryConfig(authenticationFlowContext.getAuthenticatorConfig());  
  
        if (config.shouldBypassLoginPage()) {  
            // ...  
        }  
    }  
}
```

Ensure Stability by Encapsulation

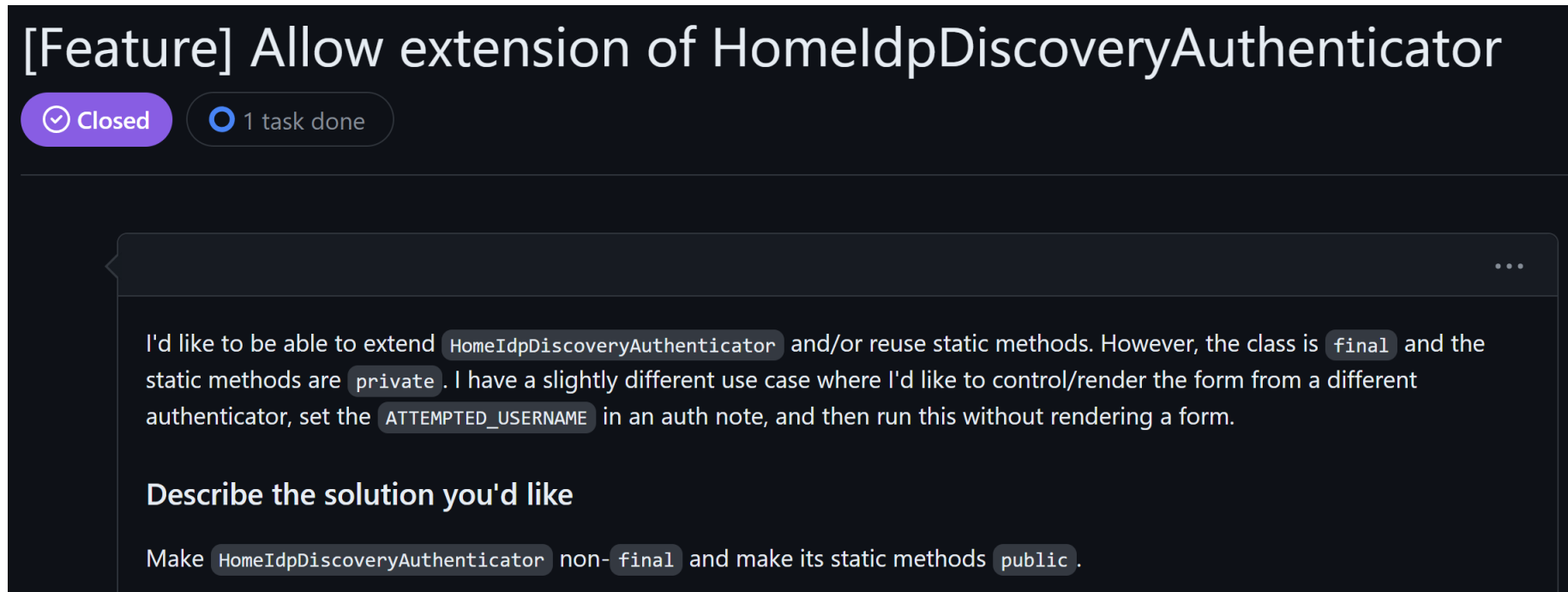
Wrap context-related code

```
final class HomeldpDiscoveryAuthenticator implements Authenticator {

    @Override
    public void authenticate(AuthenticationFlowContext authenticationFlowContext) {
        HomeldpAuthenticationFlowContext context = new HomeldpAuthenticationFlowContext(authenticationFlowContext);
        // ...
        context.rememberMe().remember(username);
    }

    void remember(String username) {
        String rememberMe = authenticationFlowContext.getAuthenticationSession().getAuthNote(Details.REMEMBER_ME);
        RealmModel realm = authenticationFlowContext.getRealm();
        boolean remember = realm.isRememberMe() && "true".equalsIgnoreCase(rememberMe);
        if (remember) {
            AuthenticationManager.createRememberMeCookie(username, authenticationFlowContext.getUriInfo(), authenticationFlowContext.getSession());
        } else {
            AuthenticationManager.expireRememberMeCookie(realm, authenticationFlowContext.getUriInfo(), authenticationFlowContext.getSession());
        }
    }
}
```

Explicitly design for extendability or prohibit it



[Feature] Allow extension of HomeIdpDiscoveryAuthenticator

🔒 Closed 1 task done

I'd like to be able to extend `HomeIdpDiscoveryAuthenticator` and/or reuse static methods. However, the class is `final` and the static methods are `private`. I have a slightly different use case where I'd like to control/render the form from a different authenticator, set the `ATTEMPTED_USERNAME` in an auth note, and then run this without rendering a form.

Describe the solution you'd like

Make `HomeIdpDiscoveryAuthenticator` non-`final` and make its static methods `public`.

- When you follow such requests, classes become part of your public API
- You are missing a crucial feature discussion with your users

Explicitly design for extendability or prohibit it

Prohibit subclassing aka „mark all classes final“

Always reduce accessibility as much as possible

- Private fields and methods
- Private constants
- Limit public methods, package protected mostly works!

If you need extendability:

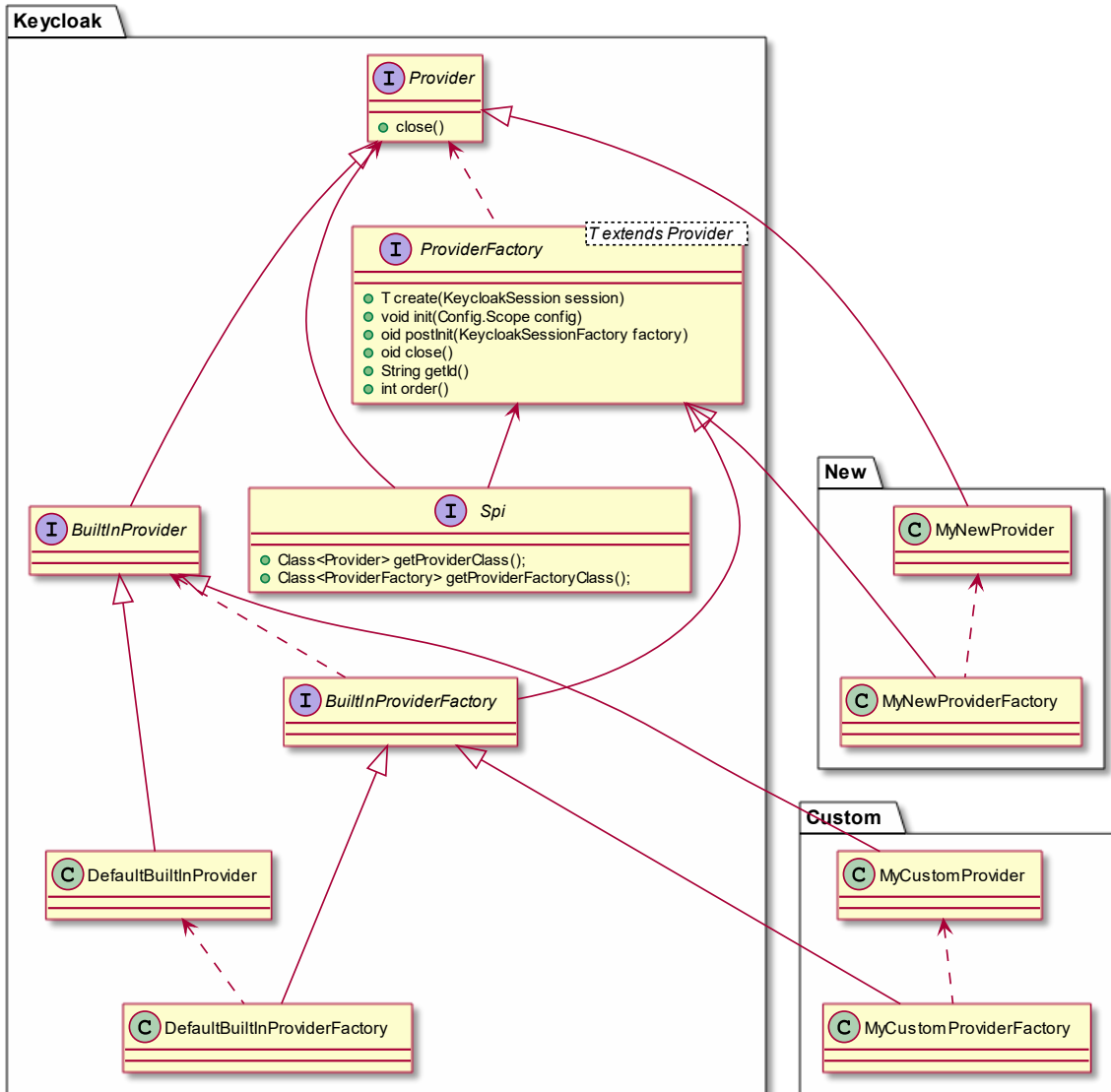
- Judiciously choose protected methods as hooks
- Use Service Provider Interfaces (SPI) to provide well defined extension points

Extensions points by SPIs



Extension points by SPIs

Keycloak Service Provider - Class Diagram



```
public interface AccessProvider extends Provider {
    boolean isRestricted(ClientModel client);

    boolean isPermitted(ClientModel client, UserModel user);

    void enableFor(ClientModel client);
}

public interface AccessProviderFactory extends ProviderFactory<AccessProvider> {
}
```

```
final class ClientRoleBasedAccessProviderFactory implements AccessProviderFactory {
    static final String PROVIDER_ID = "client-role";

    @Override
    public AccessProvider create(KeycloakSession session) {
        return new ClientRoleBasedAccessProvider();
    }

    @Override
    public String getId() {
        return PROVIDER_ID;
    }

    // ...
}

final class ClientRoleBasedAccessProvider implements AccessProvider {
    // ...
}
```

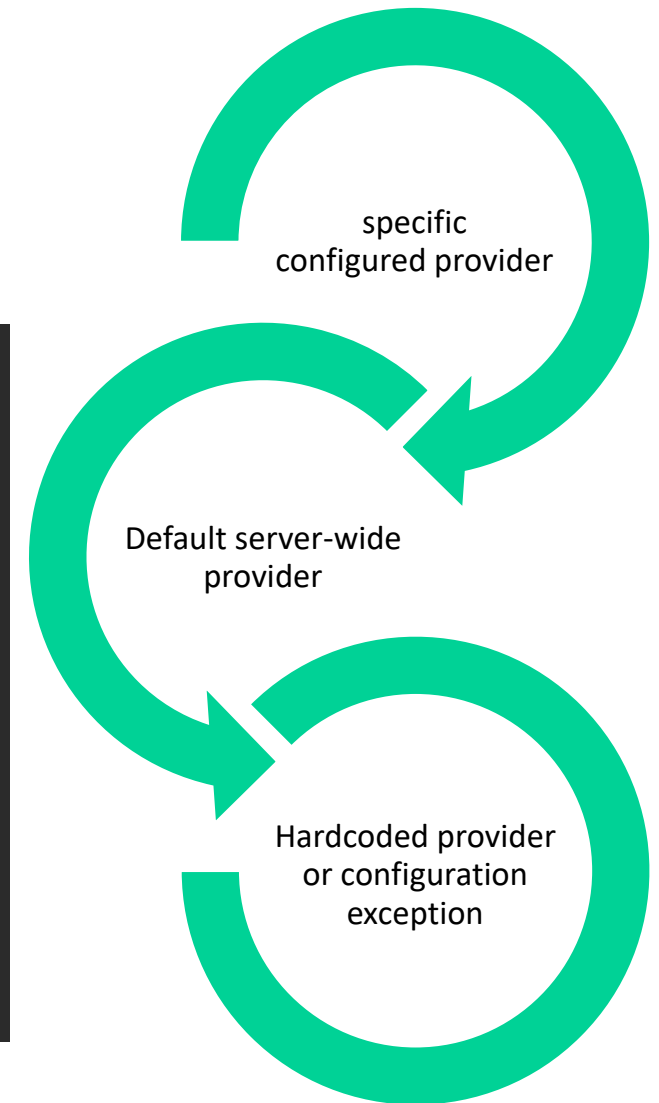
Lookup custom provider

```
private AccessProvider getAccessProvider(KeycloakSession keycloakSession, RestrictClientAuthConfig config) {
    final String accessProviderId = config.getAccessProviderId();

    // specific provider configured in authenticator config
    final AccessProvider accessProvider = keycloakSession.getProvider(AccessProvider.class, accessProviderId);
    if (accessProvider != null) {
        return accessProvider;
    }

    // default server-wide provider
    final AccessProvider defaultProvider = keycloakSession.getProvider(AccessProvider.class);
    if (defaultProvider != null) {
        return defaultProvider;
    }

    // fallback to hardcoded provider - could also throw exception here
    return keycloakSession.getProvider(AccessProvider.class, ClientRoleBasedAccessProviderFactory.PROVIDER_ID);
}
```



Keep backwards compatibility in mind:

What was the behaviour before the concept of „access provider“ existed?

REST APIs



Access control – it's not a given!

Access control is implemented in this layer!

User
Resource

Group
Resource

Custom
Resource

User Storage
Provider

Group
Provider

...

Persistence etc.

Access control – it's not a given!

```
public final class CustomRootResourceProvider implements RealmResourceProvider {  
  
    private final KeycloakSession session;  
  
    CustomRootResourceProvider(KeycloakSession session) {  
        this.session = session;  
    }  
  
    @Override  
    public Object getResource() {  
        RealmModel realm = session.getContext().getRealm();  
        CustomRootResource resource = new CustomRootResource(realm, session);  
        ResteasyProviderFactory.getInstance().injectProperties(resource);  
        resource.init();  
        return resource;  
    }  
}
```

```
auth.users().|  
    canManage(UserModel user) boolean  
    canManage() boolean  
    canQuery() boolean  
    canImpersonate() boolean  
    canImpersonate(UserModel user) boolean  
    canManageGroupMembership(UserModel user) boolean  
    canMapRoles(UserModel user) boolean  
    canView() boolean  
    canView(UserModel user) boolean  
    getAccess(UserModel user) Map<String, Boolean>  
    grantIfNoPermission(boolean grantIfNoPermission) void  
    isImpersonatable(UserModel user) boolean  
    Ctrl+Down and Ctrl+Up will move caret down and up in the editor Next Tip
```

```
void init() {  
    AuthenticationManager.AuthResult authResult = new AppAuthManager.BearerTokenAuthenticator(session).authenticate();  
    AdminAuth adminAuth = new AdminAuth(session.getContext().getRealm(), authResult.getToken(), authResult.getUser(), authResult.getClient());  
    this.auth = AdminPermissions.evaluator(session, session.getContext().getRealm(), adminAuth);  
}
```

Admin Resources – enjoy some free lunch

If you want to extend the Admin API implement **AdminRealmResourceProvider**


```
public class CustomAdminRealmResourceProvider implements AdminRealmResourceProvider {
    public CustomAdminRealmResourceProvider() {}

    @Override
    public Object getResource(KeycloakSession keycloakSession,
        RealmModel realmModel,
        AdminPermissionEvaluator adminPermissionEvaluator,
        AdminEventBuilder adminEventBuilder) {
        return new CustomAdminResource(keycloakSession, realmModel, adminPermissionEvaluator, adminEventBuilder);
    }

    @Override
    public void close() {
    }
}
```

Auditability – it's not a given either!

Events

Events are records of user and admin events in this realm. To configure the tracking of these events, go to [Event configs](#). [Learn more](#) 

User events Admin events

Refresh 1 - 3 < >

Time	Resource ...	Resource type	Operation t...	User	
February 18, 2024 at 5:35 PM		custom-resource	CREATE	2aa378b4-79d2-4ceb-a83a-d7ee5c6877b4	⋮
February 18, 2024 at 5:35 PM		custom-resource	CREATE	2aa378b4-79d2-4ceb-a83a-d7ee5c6877b4	⋮
February 18, 2024 at 5:35 PM		custom-resource	CREATE	2aa378b4-79d2-4ceb-a83a-d7ee5c6877b4	⋮

```
new AdminEventBuilder(realms, adminAuth, session, clientConnection)
    .resource("custom-resource")
    .operation(OperationType.CREATE)
    .success();
```

Time-related tasks



General use-cases

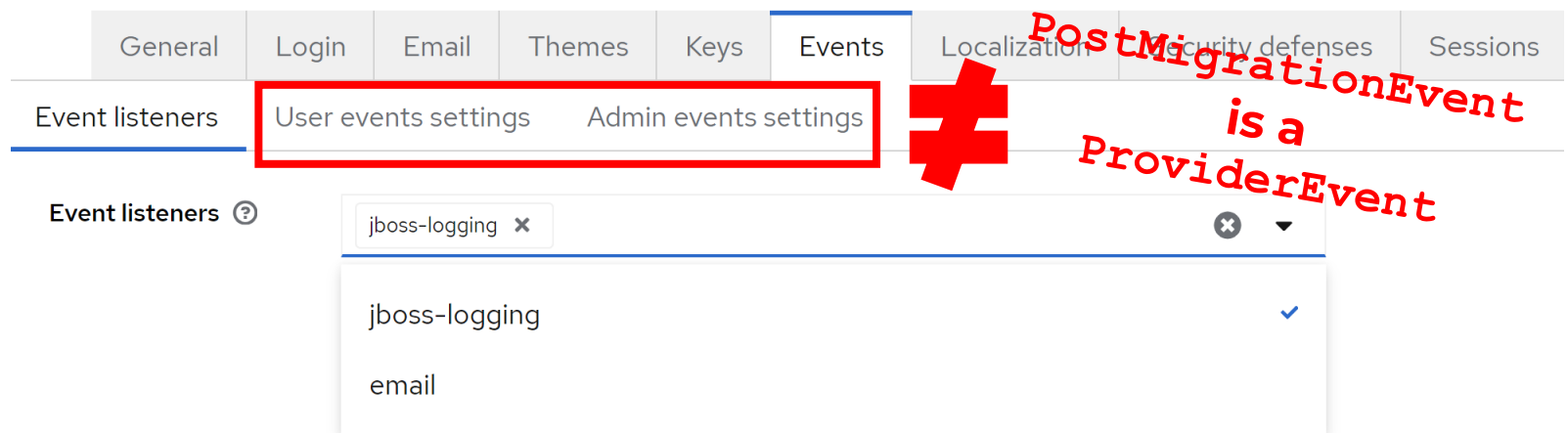
- Syncing users from custom user federations
- Cleanup jobs
 - Remove user accounts
 - Disable user accounts
- Collecting metrics

The EventListenerProvider Anti-Pattern

General pattern that I see in the wild is to implement the **EventListenerProvider**

master

Realm settings are settings that control the options for users, applications, roles, and groups in the current realm. [Learn r](#)



The screenshot shows the Keycloak Admin Console interface. The 'Events' tab is selected, and the 'User events settings' and 'Admin events settings' sections are highlighted with a red box. A red '# is a PostMigrationEvent ProviderEvent' is overlaid on the image, indicating that the implementation is not a PostMigrationEvent ProviderEvent.

Build a custom SPI

```
public final class ScheduledTaskSpi implements Spi {
```

```
    @Override
```

```
    public boolean isInternal() {  
        return true;  
    }  
}
```

```
    @Override
```

```
    public String getName() {  
        return "scheduled-task";  
    }  
}
```

```
    @Override
```

```
    public Class<? extends Provider> getProviderClass() {  
        return ScheduledTaskProvider.class;  
    }  
}
```

```
    @Override
```

```
    public Class<? extends ProviderFactory<ScheduledTaskProvider>> getProviderFactoryClass() {  
        return ScheduledTaskProviderFactory.class;  
    }  
}
```

```
interface ScheduledTaskProvider extends Provider {  
    ScheduledTask getScheduledTask();
```

```
    long getIntervall();
```

```
    String getTaskName();  
}
```


Build a custom SPI

```
public abstract class ScheduledTaskProviderFactory implements ProviderFactory<ScheduledTaskProvider> {
    private KeycloakSessionFactory keycloakSessionFactory;

    @Override
    public final void postInit(KeycloakSessionFactory keycloakSessionFactory) {
        this.keycloakSessionFactory = keycloakSessionFactory;
        keycloakSessionFactory.register((event) -> {
            if (event instanceof PostMigrationEvent) {
                KeycloakSession session = keycloakSessionFactory.create();
                TimerProvider provider = session.getProvider(TimerProvider.class);
                ScheduledTaskProvider stp = create(session);
                provider.scheduleTask(stp.getScheduledTask(), stp.getInterval(), stp.getTaskName());
            }
        });
    }

    @Override
    public final void close() {
        KeycloakSession session = keycloakSessionFactory.create();
        TimerProvider provider = session.getProvider(TimerProvider.class);
        ScheduledTaskProvider stp = this.create(session);
        provider.cancelTask(stp.getTaskName());
    }
}
```

Register new tasks

```
public final class CleanupScheduledTaskProviderFactory
    extends ScheduledTaskProviderFactory {
    @Override
    public ScheduledTaskProvider create(KeycloakSession
keycloakSession) {
        return new CleanupScheduledTaskProvider();
    }

    @Override
    public void init(Config.Scope scope) {
    }

    @Override
    public String getId() {
        return "cleanup";
    }
}
```

```
public final class CleanupScheduledTaskProvider
    implements ScheduledTaskProvider {

    @Override
    public ScheduledTask getScheduledTask() {
        return (keycloakSession -> {
            // Cleanup here
        });
    }

    @Override
    public long getIntervall() {
        return 1000;
    }

    @Override
    public String getTaskName() {
        return "test";
    }
}
```

Nice job list ;)



KEYCLOAK

master realm

Server info Provider info

Q sche x →

SPI	Add providers
scheduled-task	cleanup metrics-collector

How to configure providers?! 🙌

Remember the **ServerInfoAwareProviderFactory !**

Pro Tip: Scheduled jobs within a cluster

How to prevent running the same scheduled task on all cluster nodes?

ClusterProvider to the rescue!

```
public final class CleanupScheduledTaskProvider implements ScheduledTaskProvider {
    @Override
    public ScheduledTask getScheduledTask() {
        return (keycloakSession -> {
            ClusterProvider cluster = keycloakSession.getProvider(ClusterProvider.class);
            cluster.executelfNotExecuted(getTaskName() + "::scheduled", 1000, () -> {
                // Clean up
                return null;
            });
        });
    }
}
```

Thank you for your attention!



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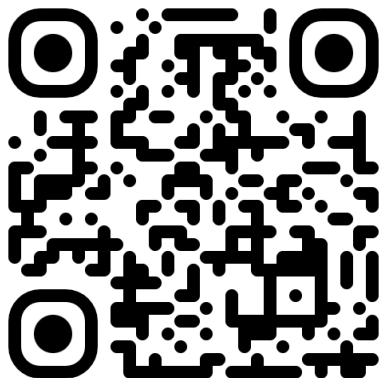


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Sven-Torben Janus

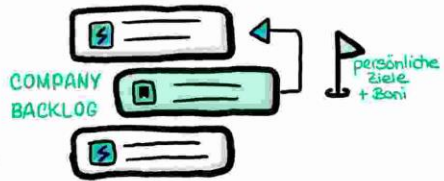
Partner, Principal Software Architect

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