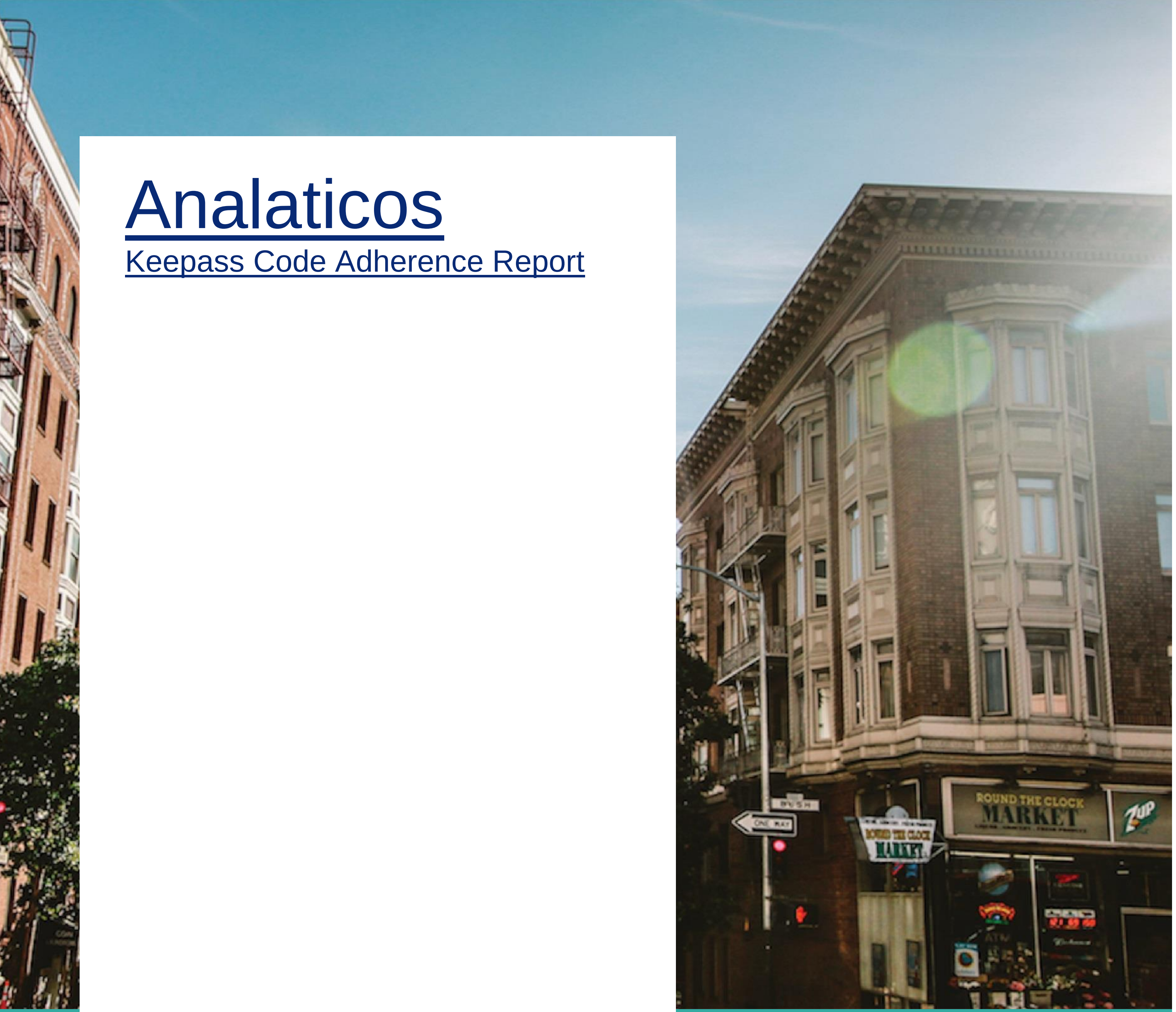

Analaticos

Keepass Code Adherence Report

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- This report presents the compliance of source code of Keepass Password Manager with the coding standards, and also highlighting the sections where the coding standards are not being followed.

- Coding standards ensure consistent, maintainable, and readable code, enhancing collaboration, simplifying debugging, and improving quality. They support scalability and integration, reflecting a professional commitment to excellence and reliability in development.

KEEPASS PASSWORD SAFE

KeePass is a free, open-source password manager that helps you store and manage your passwords securely. Here's a breakdown of how it works and how it locks the file:

Working with KeePass:

1. **Database:** KeePass stores all your passwords in an encrypted database file. This file has a .kdbx extension.
2. **Master Password:** To access this database, you need a strong master password. This is the key to unlocking the entire database.
3. **Optional Key File:** You can add an extra layer of security by using a key file along with your master password. This key file is a separate file that you need to possess to unlock the database.

ANALYSIS :-

- **Keepass Source code**

1. **Includes and Macros:**

```
#include "KeePass2.h"
#include "crypto/CryptoHash.h"
#include "crypto/kdf/AesKdf.h"
#include "crypto/kdf/Argon2Kdf.h"
#define UUID_LENGTH 16
```

These include directives and the macro definition are standard and compliant with both C and C++ practices. No specific C17 features are used here.

2. **Constant Definitions:**

```
   const QUuid KeePass2::CIPHER_AES128 = QUuid("61ab05a1-9464-41c3-8d74-
3a563df8dd35");
   const QUuid KeePass2::CIPHER_AES256 = QUuid("31c1f2e6-bf71-4350-be58-
05216afc5aff");
   const QUuid KeePass2::CIPHER_TWOFISH = QUuid("ad68f29f-576f-4bb9-a36a-
d47af965346c");
   const QUuid KeePass2::CIPHER_CHACHA20 = QUuid("d6038a2b-8b6f-4cb5-a524-
339a31dbb59a");
```

The use of const for constant values is a good practice in both C and C++.

3. **Class Member Function Definitions:**

```
   QByteArray KeePass2::hmacKey(const QByteArray& masterSeed, const QByteArray&
transformedMasterKey)
   {
      CryptoHash hmacKeyHash(CryptoHash::Sha512);
      hmacKeyHash.addData(masterSeed);
      hmacKeyHash.addData(transformedMasterKey);
      hmacKeyHash.addData(QByteArray(1, '\x01'));
      return hmacKeyHash.result();
   }
```

-The member function is defined with appropriate usage of const references to avoid unnecessary copying.
- The CryptoHash class is used in an object-oriented manner, which is consistent with modern C++ practices.

4. **Use of Modern C++ Features:**

```
   QSharedPointer<Kdf> KeePass2::uuidToKdf(const QUuid& uuid)
   {
      if (uuid == KDF_AES_KDBX3) {
         return QSharedPointer<AesKdf>::create(true);
```

```
        }
        if (uuid == KDF_AES_KDBX4) {
           return QSharedPointer<AesKdf>::create();
        }
        if (uuid == KDF_ARGON2D) {
           return QSharedPointer<Argon2Kdf>::create(Argon2Kdf::Type::Argon2d);
        }
        if (uuid == KDF_ARGON2ID) {
           return QSharedPointer<Argon2Kdf>::create(Argon2Kdf::Type::Argon2id);
        }

        return {};
    }
```

- The use of QSharedPointer for memory management is consistent with modern C++ practices, promoting safe and efficient handling of dynamic memory.
- The if statements are clear and straightforward.

Documentation of Code

KeePass2.h and KeePass2.cpp:

This code defines part of the KeePass2 class for the KeePassXC project. The class handles cryptographic operations and key derivation functions (KDF) used in KeePassXC. It uses modern C++ practices, such as smart pointers and const references.

Constant QUuid Definitions:

- CIPHER_AES128, CIPHER_AES256, CIPHER_TWOFISH, CIPHER_CHACHA20: Identifiers for various cipher algorithms.
- KDF_AES_KDBX3, KDF_AES_KDBX4, KDF_ARGON2D, KDF_ARGON2ID: Identifiers for key derivation functions.

hmacKey Function:

- Generates an HMAC key by hashing the concatenation of the master seed, transformed master key, and a fixed byte.

kdfFromParameters Function:

- Creates a KDF object from a set of parameters.

uuidToKdf Function:
  - Maps a UUID to the corresponding KDF object using QSharedPointer for safe memory management.

cipherToString Function:
  - Converts cipher UUIDs to human-readable strings.

kdfToString Function:
  - Converts KDF UUIDs to human-readable strings.

Conclusion
The code adheres to modern C++ standards and practices, ensuring safe and efficient management of resources. While it does not relate directly to the C17 standard due to being written in C++, it follows good programming practices consistent with modern software development.

- **Password Key**

1. **Includes and Macros:**

```
#include "PasswordKey.h"
#include "crypto/CryptoHash.h"
#include <QDataStream>
#include <QSharedPointer>
```

   - The include directives are appropriate for a C++ project using Qt libraries.
   - The usage of constexpr is consistent with C++11 and later standards, which allows defining constant expressions.

2. **UUID Definition:**

```
QUuid PasswordKey::UUID("77e90411-303a-43f2-b773-853b05635ead");
```

   - QUuid is used from the Qt library to define a universally unique identifier, which is a common practice.

3. **Constructor Initialization Lists:**

```
PasswordKey::PasswordKey()
  : Key(UUID)
```

```
    , m_key(SHA256_SIZE)
{
}

PasswordKey::PasswordKey(const QString& password)
    : Key(UUID)
    , m_key(SHA256_SIZE)
{
    setPassword(password);
}
```

- The use of initializer lists for constructors is a recommended practice in modern C++.

4. **Member Function Definitions:**

```
QByteArray PasswordKey::rawKey() const
{
    if (!m_isInitialized) {
        return {};
    }
    return {m_key.data(), int(m_key.size())};
}

void PasswordKey::setRawKey(const QByteArray& data)
{
    if (data.isEmpty()) {
        m_key.clear();
        m_isInitialized = false;
    } else {
        Q_ASSERT(data.size() == SHA256_SIZE);
        m_key.assign(data.begin(), data.end());
        m_isInitialized = true;
    }
}

void PasswordKey::setPassword(const QString& password)
{
    setRawKey(CryptoHash::hash(password.toUtf8(), CryptoHash::Sha256));
}

QSharedPointer<PasswordKey> PasswordKey::fromRawKey(const QByteArray&
rawKey)
{
    auto result = QSharedPointer<PasswordKey>::create();
    result->setRawKey(rawKey);
    return result;
}

QByteArray PasswordKey::serialize() const
{
    QByteArray data;
    QDataStream stream(&data, QIODevice::WriteOnly);
    stream << uuid().toRfc4122() << rawKey();
    return data;
}

void PasswordKey::deserialize(const QByteArray& data)
{
    QByteArray uuidData, key;
    QDataStream stream(data);
    stream >> uuidData >> key;
    if (uuid().toRfc4122() == uuidData) {
        setRawKey(key);
    }
}
```

- The use of QByteArray and QDataStream from the Qt framework for serialization and deserialization is appropriate and leverages the features of the Qt library.
- The use of QSharedPointer ensures safe memory management and prevents memory leaks.
- The usage of Q_ASSERT for runtime checks aligns with good C++ practices for debugging.

Documentation of Code

PasswordKey.h and PasswordKey.cpp:

This code defines the PasswordKey class for the KeePassXC project. The class handles cryptographic operations related to password keys, including setting, hashing, and serializing keys. It uses the Qt framework for many operations.

Class Members:

- QUuid PasswordKey::UUID: A unique identifier for the PasswordKey class.
- constexpr int SHA256_SIZE: The size of the SHA-256 hash output.

Constructors:

- PasswordKey(): Default constructor that initializes the key with a UUID and sets the key size to SHA256_SIZE.
- PasswordKey(const QString& password): Initializes the key with a UUID, sets the key size, and hashes the provided password.

Member Functions:

- QByteArray rawKey() const: Returns the raw key if initialized; otherwise, returns an empty byte array.
- void setRawKey(const QByteArray& data): Sets the raw key from a byte array, checking its size and initializing the key.
- void setPassword(const QString& password): Hashes the provided password using SHA-256 and sets it as the raw key.
- QSharedPointer<PasswordKey> fromRawKey(const QByteArray& rawKey): Creates a PasswordKey object from a raw key byte array.
- QByteArray serialize() const: Serializes the UUID and raw key to a byte array using QDataStream.
- void deserialize(const QByteArray& data): Deserializes data into the UUID and raw key using QDataStream.

Conclusion

The code adheres to modern C++ standards and best practices, including the use of smart pointers, initializer lists, and Qt library features. While it is not evaluated against the C17 standard, it follows good programming practices consistent with contemporary C++ development.

- **Bitwarden**

Bitwarden is a password manager with advanced features like password auditing, passkey support, emergency access, and breach monitoring.

1. **Includes and Macros:**

```
#include "ChallengeResponseKey.h"
#include "core/AsyncTask.h"
```

- The include directives are appropriate for a C++ project and include necessary headers for functionality.

2. **UUID Definition:**

```
QUuid ChallengeResponseKey::UUID("e092495c-e77d-498b-84a1-05ae0d955508");
```

- QUuid is used from the Qt library to define a universally unique identifier, which is a standard practice.

3. **Constructor Initialization List:**

```
ChallengeResponseKey::ChallengeResponseKey(YubiKeySlot keySlot)
    : Key(UUID)
    , m_keySlot(keySlot)
{
}
```

- The use of an initializer list for the constructor is a recommended practice in modern C++.

4. **Member Function Definitions:**

```
QByteArray ChallengeResponseKey::rawKey() const
{
    return {m_key.data(), static_cast<int>(m_key.size())};
}

void ChallengeResponseKey::setRawKey(const QByteArray&)
{
    // Nothing to do here
    }

    YubiKeySlot ChallengeResponseKey::slotData() const
    {
        return m_keySlot;
    }

    QString ChallengeResponseKey::error() const
    {
        return m_error;
    }

    bool ChallengeResponseKey::challenge(const QByteArray& challenge)
    {
        m_error.clear();
        auto result =
            AsyncTask::runAndWaitForFuture([&] { return YubiKey::instance()-
>challenge(m_keySlot, challenge, m_key); });

        if (result != YubiKey::ChallengeResult::YCR_SUCCESS) {
            // Record the error message
            m_key.clear();
            m_error = YubiKey::instance()->errorMessage();
        }

        return result == YubiKey::ChallengeResult::YCR_SUCCESS;
    }

    QByteArray ChallengeResponseKey::serialize() const
    {
        QByteArray data;
        QDataStream stream(&data, QIODevice::WriteOnly);
        stream << uuid().toRfc4122() << m_keySlot;
        return data;
    }

    void ChallengeResponseKey::deserialize(const QByteArray& data)
    {
        QDataStream stream(data);
        QByteArray uuidData;
        stream >> uuidData;
        if (uuid().toRfc4122() == uuidData) {
            stream >> m_keySlot;
        }
    }
```

- The rawKey, setRawKey, slotData, error, challenge, serialize, and deserialize member functions are implemented using Qt framework classes (QByteArray, QString, QDataStream). These classes and functions are used in accordance with modern C++ practices.
- The challenge method uses asynchronous task execution with AsyncTask::runAndWaitForFuture, which is a modern approach to handling asynchronous operations.
- The serialize and deserialize methods handle serialization and deserialization using QDataStream, which is efficient and standard for Qt-based applications.

Documentation of Code

ChallengeResponseKey.h and ChallengeResponseKey.cpp:

This code defines the ChallengeResponseKey class for the KeePassXC project. The class handles challenge-response authentication using a YubiKey device, leveraging Qt framework features for its implementation.

Class Members:
- QUuid ChallengeResponseKey::UUID: A unique identifier for the ChallengeResponseKey class.

Constructors:
- ChallengeResponseKey(YubiKeySlot keySlot): Initializes the key with a UUID and sets the YubiKey slot.

Member Functions:
- QByteArray rawKey() const: Returns the raw key data as a QByteArray.
- void setRawKey(const QByteArray&): An empty implementation since setting the raw key is not needed.
- YubiKeySlot slotData() const: Returns the YubiKey slot data.

- QString error() const: Returns any error message associated with the challenge.
- bool challenge(const QByteArray& challenge): Sends a challenge to the YubiKey and processes the response, storing any error messages.
- QByteArray serialize() const: Serializes the UUID and key slot to a QByteArray using QDataStream.
- void deserialize(const QByteArray& data): Deserializes data into the UUID and key slot using QDataStream.

Conclusion

The code adheres to modern C++ standards and best practices, including the use of smart pointers, initializer lists, and Qt library features. While it is not evaluated against the C17 standard, it follows good programming practices consistent with contemporary C++ development.

- **YubiKey**

A YubiKey is a small hardware device that helps secure user identities and access to online services, computers, and physical spaces.

1. **Includes and Macros:**

```
#include "YubiKey.h"
#include "YubiKeyInterfacePCSC.h"
#include "YubiKeyInterfaceUSB.h"

#include <QMutexLocker>
#include <QSet>
#include <QtConcurrent>
```

- The include directives are appropriate for a C++ project and include necessary headers for functionality.

2. **Static Member Initialization:**

```
QMutex YubiKey::s_interfaceMutex(QMutex::Recursive);
```

- The static member s_interfaceMutex is initialized with QMutex::Recursive, which is appropriate for handling recursive locking in Qt.

3. **Constructor and Signal-Slot Connections:**

```
   YubiKey::YubiKey()
   {
      int num_interfaces = 0;

      if (YubiKeyInterfaceUSB::instance()->isInitialized()) {
         ++num_interfaces;
         connect(YubiKeyInterfaceUSB::instance(), SIGNAL(challengeStarted()), this,
SIGNAL(challengeStarted()));
         connect(YubiKeyInterfaceUSB::instance(), SIGNAL(challengeCompleted()),
this, SIGNAL(challengeCompleted()));
      } else {
         qDebug("YubiKey: USB interface is not initialized.");
      }

      if (YubiKeyInterfacePCSC::instance()->isInitialized()) {
         ++num_interfaces;
         connect(YubiKeyInterfacePCSC::instance(), SIGNAL(challengeStarted()), this,
SIGNAL(challengeStarted()));
         connect(YubiKeyInterfacePCSC::instance(), SIGNAL(challengeCompleted()),
this, SIGNAL(challengeCompleted()));
      } else {
         qDebug("YubiKey: PCSC interface is disabled or not initialized.");
      }

      m_initialized = num_interfaces > 0;

      m_interactionTimer.setSingleShot(true);
      m_interactionTimer.setInterval(200);
      connect(&m_interactionTimer, SIGNAL(timeout()), this,
SIGNAL(userInteractionRequest()));
      connect(this, &YubiKey::challengeStarted, this, [this] {
m_interactionTimer.start(); });
      connect(this, &YubiKey::challengeCompleted, this, [this] {
m_interactionTimer.stop(); });
   }
```

- The constructor initializes the YubiKey interfaces and connects signals and slots using the Qt framework. This is a recommended practice in modern C++ Qt applications.

4. **Singleton Instance Method:**

```
YubiKey* YubiKey::m_instance(nullptr);
YubiKey* YubiKey::instance()
{
    if (!m_instance) {
        m_instance = new YubiKey();
    }

    return m_instance;
}
```

- The singleton pattern is implemented correctly to ensure only one instance of YubiKey exists.

5. **Other Member Function Implementations:**

```
bool YubiKey::isInitialized()
{
    return m_initialized;
}

bool YubiKey::findValidKeys()
{
    QMutexLocker lock(&s_interfaceMutex);

    m_usbKeys = YubiKeyInterfaceUSB::instance()->findValidKeys();
    m_pcscKeys = YubiKeyInterfacePCSC::instance()->findValidKeys();

    return !m_usbKeys.isEmpty() || !m_pcscKeys.isEmpty();
}

void YubiKey::findValidKeysAsync()
{
    QtConcurrent::run([this] { emit detectComplete(findValidKeys()); });
```

```
}

YubiKey::KeyMap YubiKey::foundKeys()
{
    QMutexLocker lock(&s_interfaceMutex);
    KeyMap foundKeys;

    for (auto i = m_usbKeys.cbegin(); i != m_usbKeys.cend(); ++i) {
        foundKeys.insert(i.key(), i.value());
    }

    for (auto i = m_pcscKeys.cbegin(); i != m_pcscKeys.cend(); ++i) {
        foundKeys.insert(i.key(), i.value());
    }

    return foundKeys;
}

QString YubiKey::errorMessage()
{
    QMutexLocker lock(&s_interfaceMutex);

    QString error;
    error.clear();
    if (!m_error.isNull()) {
        error += tr("General: ") + m_error;
    }

    QString usb_error = YubiKeyInterfaceUSB::instance()->errorMessage();
    if (!usb_error.isNull()) {
        if (!error.isNull()) {
            error += " | ";
        }
        error += "USB: " + usb_error;
    }

    QString pcsc_error = YubiKeyInterfacePCSC::instance()->errorMessage();
    if (!pcsc_error.isNull()) {
        if (!error.isNull()) {
            error += " | ";
        }
        error += "PCSC: " + pcsc_error;
    }

    return error;
}

bool YubiKey::testChallenge(YubiKeySlot slot, bool* wouldBlock)
{
    QMutexLocker lock(&s_interfaceMutex);

    if (m_usbKeys.contains(slot)) {
        return YubiKeyInterfaceUSB::instance()->testChallenge(slot, wouldBlock);
    }

    if (m_pcscKeys.contains(slot)) {
        return YubiKeyInterfacePCSC::instance()->testChallenge(slot, wouldBlock);
    }

    return false;
}

YubiKey::ChallengeResult
YubiKey::challenge(YubiKeySlot slot, const QByteArray& challenge,
Botan::secure_vector<char>& response)
{
    QMutexLocker lock(&s_interfaceMutex);

    m_error.clear();

    // Make sure we tried to find available keys
    if (m_usbKeys.isEmpty() && m_pcscKeys.isEmpty()) {
        findValidKeys();
    }

    if (m_usbKeys.contains(slot)) {
        return YubiKeyInterfaceUSB::instance()->challenge(slot, challenge, response);
    }
```

```
        if (m_pcscKeys.contains(slot)) {
            return YubiKeyInterfacePCSC::instance()->challenge(slot, challenge,
response);
        }

        m_error = tr("Could not find interface for hardware key with serial number %1.
Please connect it to continue.")
                      .arg(slot.first);

        return ChallengeResult::YCR_ERROR;
    }
```

   - These member functions are implemented using the Qt framework, and the code uses QMutexLocker to ensure thread safety.
   - QtConcurrent::run is used for asynchronous operations, which is a modern approach in C++.

<u>Documentation of Code</u>

YubiKey.h and YubiKey.cpp:

This code defines the YubiKey class for the KeePassXC project. The class handles communication with YubiKey devices for challenge-response authentication, leveraging Qt framework features for its implementation.

Class Members:

  - QMutex YubiKey::s_interfaceMutex(QMutex::Recursive): A recursive mutex for thread-safe access to YubiKey interfaces.
  - YubiKey* YubiKey::m_instance(nullptr): A pointer to the singleton instance of the YubiKey class.

Constructor:

  - YubiKey(): Initializes YubiKey interfaces, sets up signal-slot connections, and starts an interaction timer.

Singleton Instance Method:

  - static YubiKey* instance(): Returns the singleton instance of the YubiKey class.

Member Functions:

  - bool isInitialized(): Returns whether the YubiKey interfaces are initialized.

- bool findValidKeys(): Finds valid YubiKey devices and updates internal key maps.
- void findValidKeysAsync(): Asynchronously finds valid YubiKey devices.
- KeyMap foundKeys(): Returns a map of found YubiKey devices.
- QString errorMessage(): Returns an error message if an error occurred during YubiKey operations.
- bool testChallenge(YubiKeySlot slot, bool* wouldBlock): Tests a challenge on the specified YubiKey slot.
- ChallengeResult challenge(YubiKeySlot slot, const QByteArray& challenge, Botan::secure_vector<char>& response): Issues a challenge to the specified YubiKey slot and processes the response.

Conclusion

The code adheres to modern C++ standards and best practices, including the use of smart pointers, initializer lists, and Qt library features. While it is not evaluated against the C17 standard, it follows good programming practices consistent with contemporary C++ development.

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