Faces

Module Description

In this module, we will learn about the faces, how to create faces, what are the components of faces, how are they managed, and how to use them.

Procedure

Faces are the main component of the NDN architecture. They act as the abstraction over the communication channel over the `NetDevice` and the `Node` class.

Faces can be either of external type created due to the presence of a `NetDevice` or internal type created due to the presence of a `Application` class.

FaceManager

1. Faces are created by the `FaceManager` class.
2. The `FaceManager` class is a singleton class that manages all the faces in the system.
3. The ownership of the `Face` class object is with the `FaceManager` class.
4. The `FaceManager` class is responsible for creating, deleting, and managing the faces in the system.

FaceTable

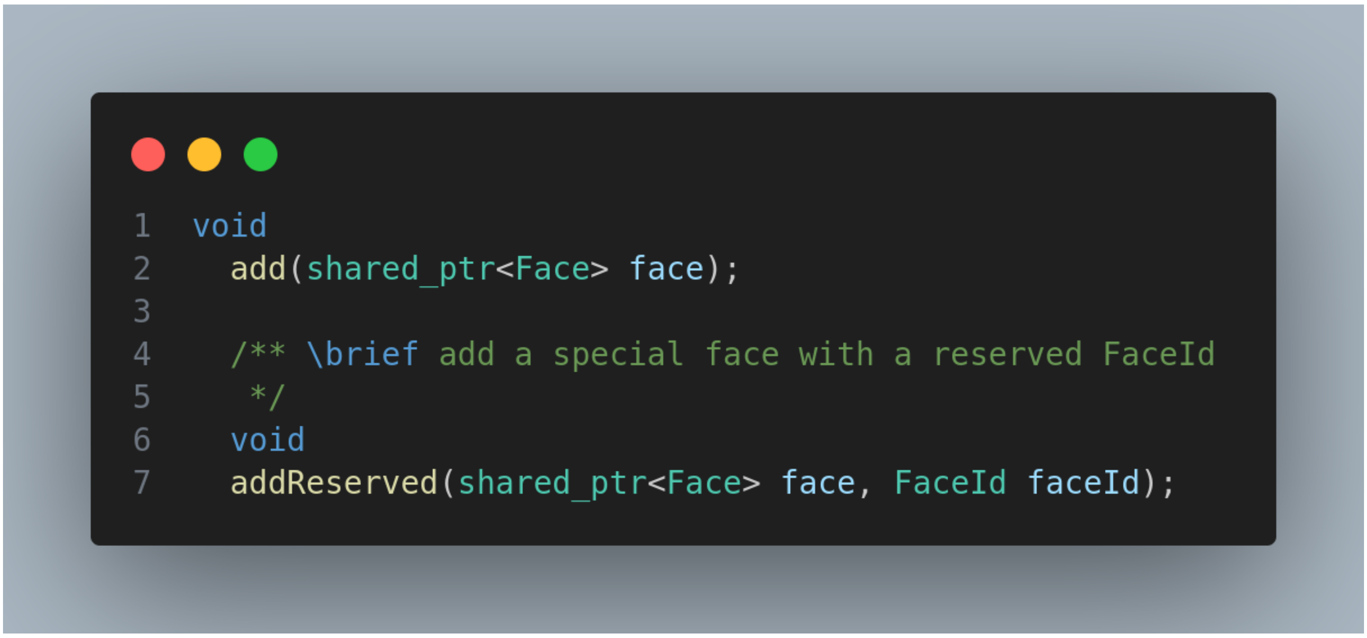
The `FaceTable` class is a container class that stores all the faces in the system.

Other

Note that, the `Face` class object is not same as normal C++ object. It is non mutable singleton component in the system, so we must make use of smart pointer to access the `Face` class object.

If we didn't care to use the smart pointer, then we will get a multiple copies of the same `Face` class object and the system will not work as expected as the `Face` class object is a singleton class and we work multiple independent copies of the same object.

Link to the FaceTable class source code.

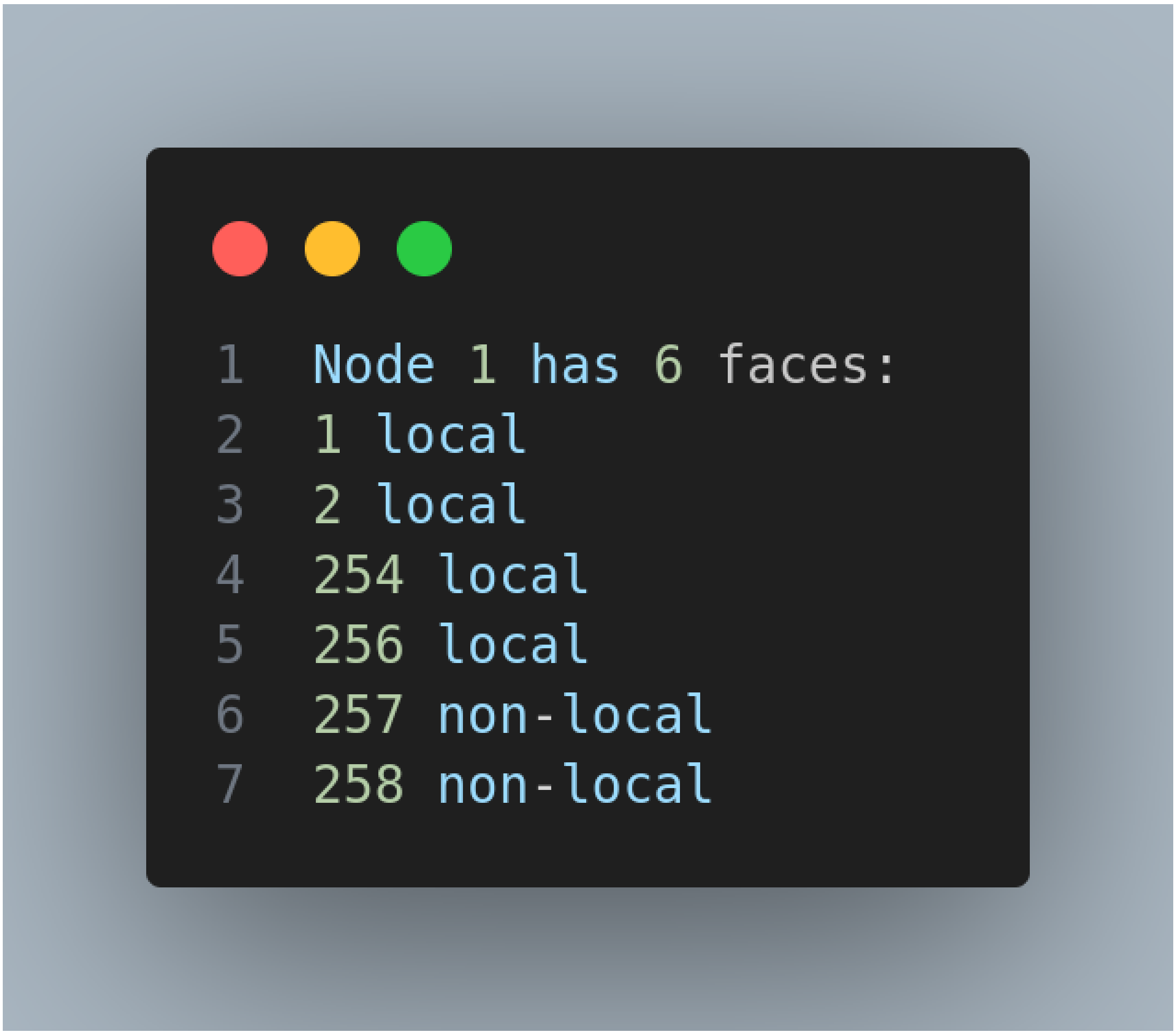


```
void
  add(shared_ptr<Face> face);

  /** \brief add a special face with a reserved FaceId
   */
  void
  addReserved(shared_ptr<Face> face, FaceId faceId);
```

> 1. This above picture shows a snippet from the `FaceTable` class.
>
> 2. Notice the use of smart pointer `shared_ptr` to access the `Face` class object.
>
> 3. `FaceTable` uses `std::map<FaceId, shared_ptr<Face>>` to store the faces in the system.

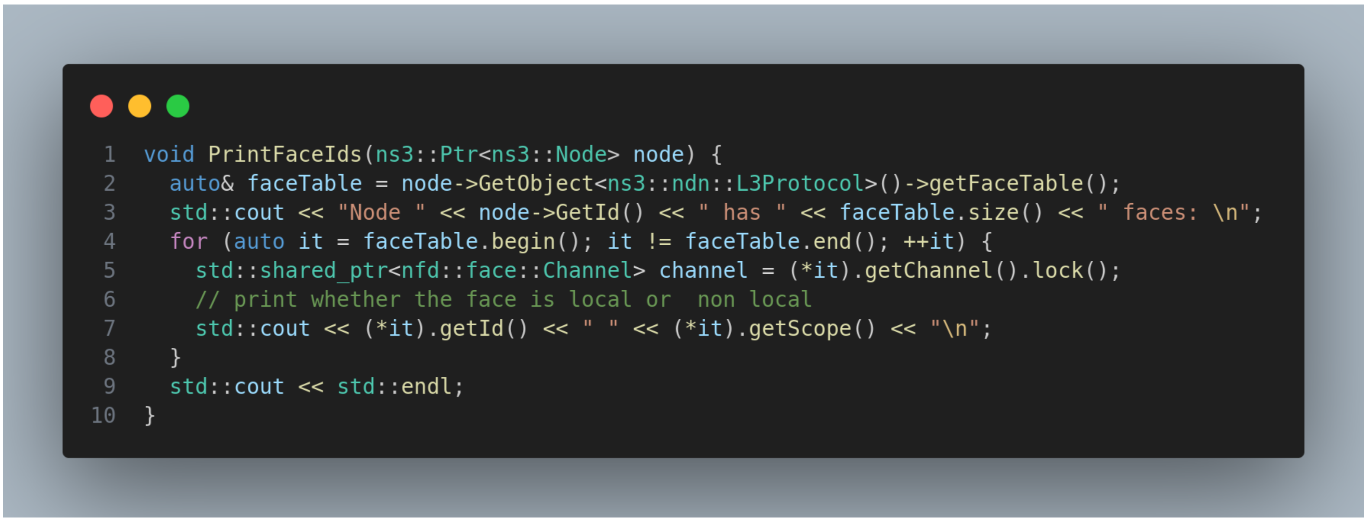
The `FaceId` assinged to the `Face` is defined by the scope of the `Face` class object. If it is non-local, we can expect the `FaceId` to be greater than 256.



```
Node 1 has 6 faces:
1 local
2 local
254 local
256 local
257 non-local
258 non-local
```

> 1. This above picture is an example for the `FaceId` retrieved from the `FaceTable`.
>
> 2. It shows, that the particular node has 6 faces in the system with 4 being local and 2 being non-local.

Below is a code snippet on how to retrieve this info from the ns-3 `Node` class.



```
void PrintFaceIds(ns3::Ptr<ns3::Node> node) {
  auto& faceTable = node->GetObject<ns3::ndn::L3Protocol>()->getFaceTable();
  std::cout << "Node " << node->GetId() << " has " << faceTable.size() << " faces: \n";
  for (auto it = faceTable.begin(); it != faceTable.end(); ++it) {
    std::shared_ptr<nfd::face::Channel> channel = (*it).getChannel().lock();
    // print whether the face is local or  non local
    std::cout << (*it).getId() << " " << (*it).getScope() << "\n";
  }
  std::cout << std::endl;
}
```

Internal components of the Face class

1. The `Face` class is made of two other classes which manages different abstraction layer of this class.

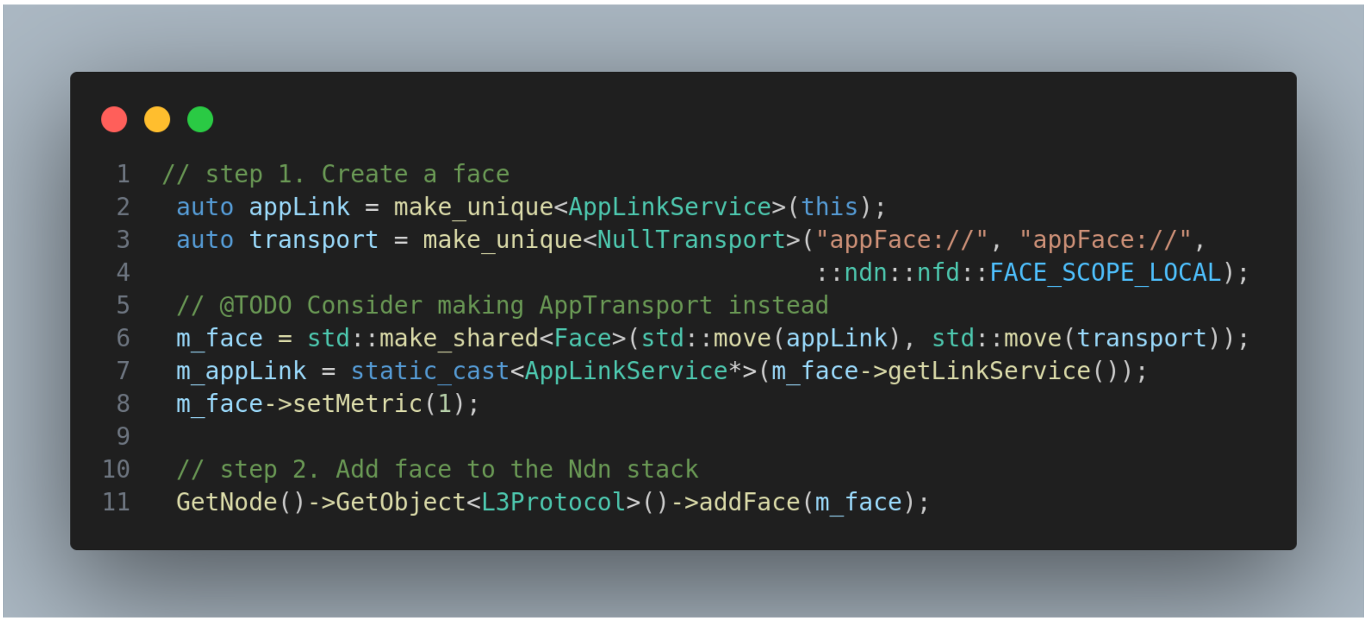
2. The two classes are `Transport` and `LinkService` class. Without any of these, the `Face` class is incomplete.

3. This can be seen from the face that the only constructor available for the `Face` class to create a object is of the form

```
Face(unique_ptr<LinkService> service, unique_ptr<Transport> transport);
```

4. The `Transport` class is responsible for the communication channel between the `Face` class and the `NetDevice` class.

5. The `LinkService` class is responsible for the communication channel between the `Face` class and the `Application` class.

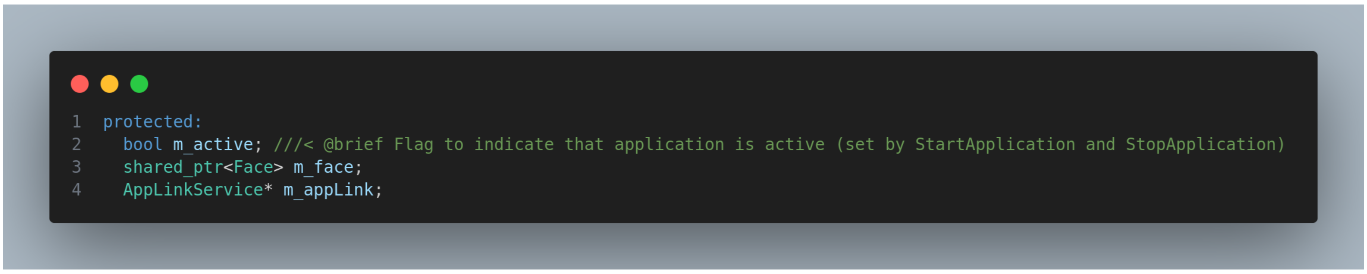


```
// step 1. Create a face
 auto appLink = make_unique<AppLinkService>(this);
 auto transport = make_unique<NullTransport>("appFace://", "appFace://",
                                             ::ndn::nfd::FACE_SCOPE_LOCAL);
 // @TODO Consider making AppTransport instead
 m_face = std::make_shared<Face>(std::move(appLink), std::move(transport));
 m_appLink = static_cast<AppLinkService*>(m_face->getLinkService());
 m_face->setMetric(1);

 // step 2. Add face to the Ndn stack
 GetNode()->GetObject<L3Protocol>()->addFace(m_face);
```

> The above picture shows how `Application` class is creating it's own `Face` class with it's own `AppLinkService` class object and `NullTransport` and attaching it to the `L3protocol` class.

6. The `LinkService` object comes in various types depending on the scope where it used. `AppLinkService` is used for the internal faces for communication between the `Face` class and the `Application` class internally.



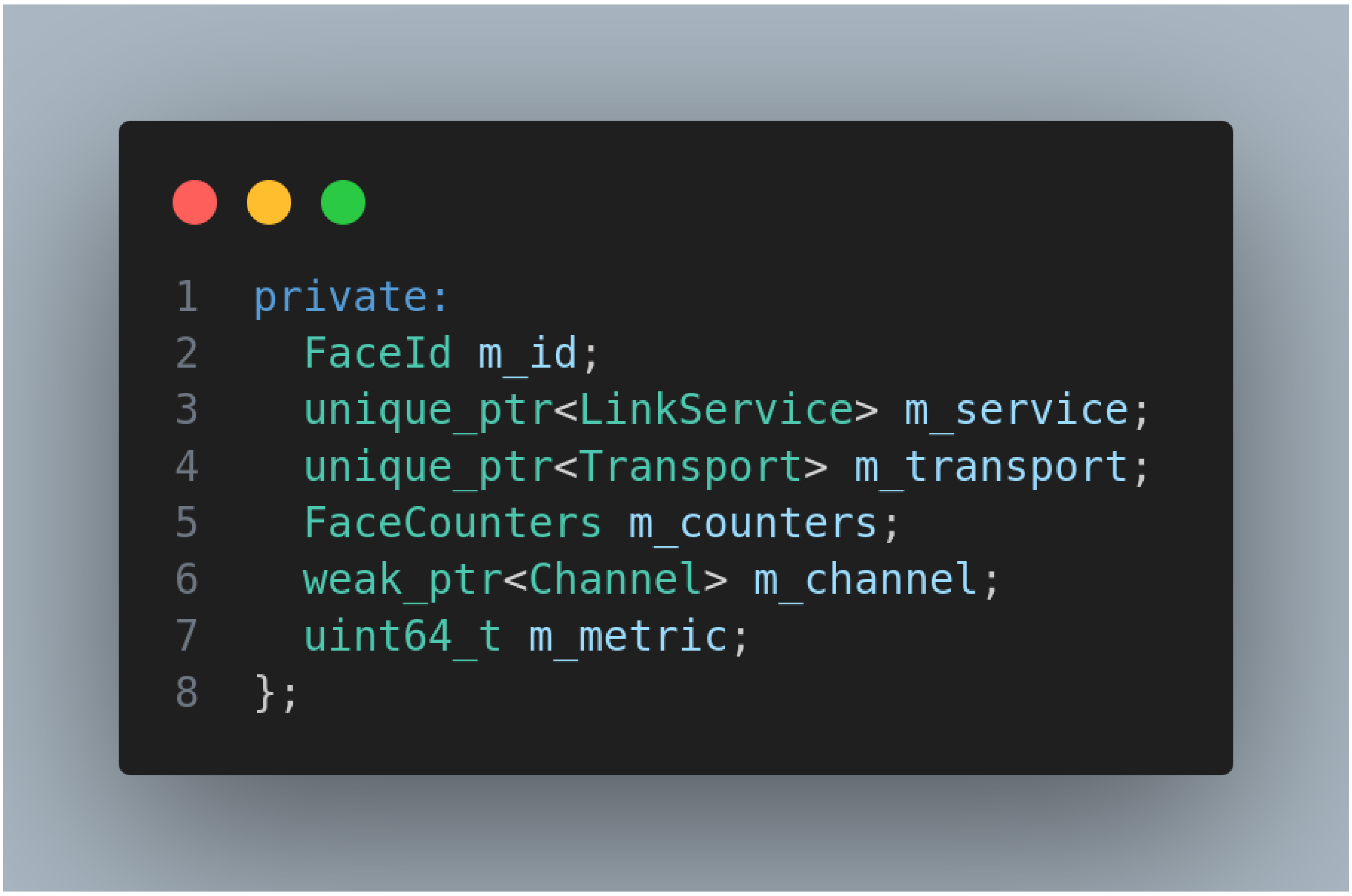
```
protected:
  bool m_active; ///< @brief Flag to indicate that application is active (set by StartApplication and StopApplication)
  shared_ptr<Face> m_face;
  AppLinkService* m_appLink;
```

> 1. This above picture shows the protected member variables of the `App` class that inherits from the `Application` class.

> 2. See the `m_appLink` variable which is of type `AppLinkService`. Also notice that we didn't use the smart pointer to access the `AppLinkService` class object despite the fact that the `Face` object that it is pointing to is a singleton class.
>
> 3. This is because the `AppLinkService` class object is created by the `Application` class when staring the Application and is destroyed when the application is stopped. So, we don't need to worry about the ownership of the `AppLinkService` class object.
>
> 4. In fact, the `Face` class also doesn't want the ownership of the `AppLinkService`, that is why it is using the unique pointer to access the `AppLinkService` class object.
>
> 5. But for the `Face` class object, we intend to use the smart pointer because it is managed by `FaceManager` class.

External components of the Face class

Here we will discuss about other functionalities of the `Face` class that is provided out of the box.



```
private:
  FaceId m_id;
  unique_ptr<LinkService> m_service;
  unique_ptr<Transport> m_transport;
  FaceCounters m_counters;
  weak_ptr<Channel> m_channel;
  uint64_t m_metric;
};
```

> 1. This above picture shows the private member variables of the `Face` class.
>
> 2. `FaceCounters` are used by the Tracers to get the statistics of the `Face` class. i.e. the number of interest/data packets sent, received, dropped, etc.
>
> 3. `m_metric` is used by the `Face` class to calculate the metric of the `Face` class object. This metric is used by the `Strategy` class to make the forwarding decision. (Cost based forwarding)
>
> 4. `m_channel` is used by the `Face` class to get the `Channel` class object. This `Channel` class object is the underlying communication channel between the `Face` class and the `NetDevice`

> class.

The `Face` class can be segregated based on the anotomy of number of endpoints in the system.

1. Point-to-Point (i.e wired link)
2. Multipoint (i.e ethernet)
3. Ad-hoc (i.e wireless)

Each endpoint is uniquely identified by the `FaceUri` class object.

Refer this link for more on FaceUri

Link for the FaceUri source code.