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Transceiver Facility Native C++ PSM specification

1 Introduction

This document WINNF-TS-0008-App01 is the native C++ PSM specification of the Transceiver Facility V2.1.0.

It derives from the Transceiver Facility PIM Specification [Ref1] in accordance with Principles for WInnForum Facility Standards [Ref2].

It addresses the Native C++ programming paradigm, applying the mapping rules of the Native C++ section of WInnForum Facilities PSMs Mapping Rules [Ref3] and specifically reporting any deviation to those rules.

The following figure positions the interfaces addressed by the native C++ PSM specification:

As depicted, the native C++ PSM specification addresses the native C++ PSM interfaces of transceivers, positioned, within a native C++ node, between the native C++ application components of radio applications and native C++ façades of native C++ transceivers.

The native C++ PSM specification addresses two versions of the C++ language:
- C++03, specified by [Ref4], typically applicable for DSP (Digital Signal Processors) processing nodes where compilers do not support recent C++ language versions,
- C++11, specified by [Ref5], suited to state-of-the art programming environments.

It uses the abbreviation “xvcr” to identify Transceiver Facility in formal identifiers.

1.1 Reference definitions

The Transceiver Facility native C++ PSM specification applies the following definitions from Transceiver Facility PIM Specification [Ref1]:

<table>
<thead>
<tr>
<th>Topic</th>
<th>Used definitions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transceiver technical concepts</td>
<td>transceiver, Transceiver Facility, Tx channel, Rx channel</td>
</tr>
</tbody>
</table>

Table 1 Definitions from Transceiver Facility PIM Specification
The *Transceiver Facility native C++ PSM specification* applies the following definitions from *Principles for WInnForum Facility Standards* [Ref2]:

<table>
<thead>
<tr>
<th>Topic</th>
<th>Applied definitions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base concepts</td>
<td>radio application, radio platform</td>
</tr>
<tr>
<td>Architecture concepts</td>
<td>application component, processing node, façade</td>
</tr>
<tr>
<td>WInnForum facility</td>
<td>facility, PIM specification, PSM specification</td>
</tr>
<tr>
<td>Services</td>
<td>service, service interface, provide service, use service, services group</td>
</tr>
<tr>
<td>Primitives</td>
<td>primitive, parameter, type, exception</td>
</tr>
<tr>
<td>Attributes</td>
<td>attribute, property</td>
</tr>
</tbody>
</table>

**Table 2** Definitions from *Principles for WInnForum Facility Standards*

The *Transceiver Facility native C++ PSM specification* applies the following definitions from the Native C++ section of *WInnForum Facilities PSMs Mapping Rules* [Ref3]:

<table>
<thead>
<tr>
<th>Topic</th>
<th>Used definitions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specification purpose</td>
<td>native C++ PSM specification, native C++ PSM interface</td>
</tr>
<tr>
<td>Software architecture</td>
<td>native C++ application component, native C++ node, native C++ façade</td>
</tr>
</tbody>
</table>

**Table 3** Definitions from Native C++ section of *WInnForum Facilities PSMs Mapping Rules*

The term “unspecified” indicates an aspect explicitly left to implementer’s decisions.

### 1.2 Conformance

#### 1.1.1 Radio platform items

A *native C++ façade* of a transceiver implementation is conformant with the *Transceiver Facility native C++ PSM specification* if it provides an implementation of the *Facade* class and its related service interfaces.

A *native C++ transceiver* is defined as a transceiver implementation with all of its *native C++ façades* being conformant with the *native C++ PSM specification*.

#### 1.1.2 Radio application items

A *native C++ application component* is conformant with the *Transceiver Facility native C++ PSM specification* if it can use *native C++ façades* conformant with the *native C++ PSM specification*, without using any non-standard service interface for the transceiver.

### 1.3 Document structure

Section 2 specifies the normative classes for the *native C++ PSM interfaces*.

Section 3 specifies the header files to be used by *native C++ transceivers*. 
2 Native C++ PSM classes

This normative section specifies the C++ classes for native C++ PSM interfaces.

2.1 Provide and Use Services Interfaces

The service interfaces for the provide services of the native C++ PSM interfaces are specified by the following table:

<table>
<thead>
<tr>
<th>PIM service interface (in Transceiver::)</th>
<th>PIM section</th>
<th>Native C++ PSM service interface (in WInnF_Cpp::Transceiver::)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Management::Reset</td>
<td>2.4.1.1</td>
<td>Management::Reset</td>
</tr>
<tr>
<td>Management::RadioSilence</td>
<td>2.4.1.2</td>
<td>Management::RadioSilence</td>
</tr>
<tr>
<td>BurstControl::DirectCreation</td>
<td>2.4.2.1</td>
<td>BurstControl::DirectCreation</td>
</tr>
<tr>
<td>BurstControl::RelativeCreation</td>
<td>2.4.2.2</td>
<td>BurstControl::RelativeCreation</td>
</tr>
<tr>
<td>BurstControl::AbsoluteCreation</td>
<td>2.4.2.3</td>
<td>BurstControl::AbsoluteCreation</td>
</tr>
<tr>
<td>BurstControl::StrobedCreation</td>
<td>2.4.2.4</td>
<td>BurstControl::StrobedCreation</td>
</tr>
<tr>
<td>BurstControl::Termination</td>
<td>2.4.2.5</td>
<td>BurstControl::Termination</td>
</tr>
<tr>
<td>BasebandSignal::SamplesTransmission</td>
<td>2.4.3.2</td>
<td>BasebandSignal::SamplesTransmission</td>
</tr>
<tr>
<td>BasebandSignal::RxPacketsLengthControl</td>
<td>2.4.3.3</td>
<td>BasebandSignal::RxPacketsLengthControl</td>
</tr>
<tr>
<td>Tuning::InitialTuning</td>
<td>2.4.4.1</td>
<td>Tuning::InitialTuning</td>
</tr>
<tr>
<td>Tuning::Retuning</td>
<td>2.4.4.2</td>
<td>Tuning::Retuning</td>
</tr>
<tr>
<td>GainControl::GainLocking</td>
<td>2.4.6.2</td>
<td>GainControl::GainLocking</td>
</tr>
<tr>
<td>TransceiverTime::TimeAccess</td>
<td>2.4.7.1</td>
<td>TransceiverTime::TimeAccess</td>
</tr>
<tr>
<td>Strobing::ApplicationStrobe</td>
<td>2.4.8.1</td>
<td>Strobing::ApplicationStrobe</td>
</tr>
</tbody>
</table>

Table 4 Provide services mapping

The service interfaces for the use services of the native C++ PSM interfaces are specified by the following table:

<table>
<thead>
<tr>
<th>PIM service interface (in Transceiver::)</th>
<th>PIM section</th>
<th>Native C++ PSM service interface (in WInnF_Cpp::Transceiver::)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BasebandSignal::SamplesReception</td>
<td>2.4.3.1</td>
<td>BasebandSignal::SamplesReception</td>
</tr>
<tr>
<td>Notifications::Events</td>
<td>2.4.5.1</td>
<td>Notifications::Events</td>
</tr>
<tr>
<td>Notifications::Errors</td>
<td>2.4.5.2</td>
<td>Notifications::Errors</td>
</tr>
<tr>
<td>GainControl::GainChanges</td>
<td>2.4.6.1</td>
<td>GainControl::GainChanges</td>
</tr>
</tbody>
</table>

Table 5 Use services mapping

2.2 Facade classes

The WInnF_Cpp::Transceiver::TxFacade class is specified as the class dedicated to Tx channels, derived from the Facade class of the Native C++ section of WInnForum Facilities PSMs Mapping Rules [Ref3].
The **WInnF_Cpp::Transceiver::RxFacade** class is specified as the class dedicated to Rx channels, derived from the Facade class of the Native C++ section of WInnForum Facilities PSMs Mapping Rules [Ref3].

Since a transceiver features a CONFIGURED state, the Facade class features the methods `activeServicesInitialized()` and `activeServicesReleased()`.

Two classes are available for active services access, as specified by [Ref3]:
- ExplicitServicesAccess,
- GenericServicesAccess.

Usage of those classes by façades is controlled by the preprocessing variables `EXPLICIT_SERVICES_ACCESS` and `GENERIC_SERVICES_ACCESS`.

A façade may implement the two possibilities, in which case the two preprocessing variables are set.

Typical possibilities for the **TxFacade** and **RxFacade** classes are represented by the following class diagram:

![Class diagram of Native C++ Facades](image)

The lifecycle of a Façade instance is greater than the lifecycle of the application component using the transceiver. Other aspects are unspecified.

### 2.2.1 TxFacade

**TxFacade** owns the transceiver-specific `getSamplesTransmission()` primitive.
2.2.1.1  getSamplesTransmission method

2.2.1.1.1  Overview

getSamplesTransmission() returns a pointer referencing the instance of SamplesTransmission interface implemented by the native C++ façade for the required Tx channel.

2.2.1.1.2  Associated properties

Not applicable.

2.2.1.1.3  Declaration

The C++ signature of the method is specified as:

```cpp
Transceiver::BasebandSignal::SamplesTransmission* getSamplesTransmission(
    uint16_t channelNumber);
```

2.2.1.1.4  Parameters

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>channelNumber</td>
<td>uint16_t</td>
<td>Number of the required Tx channel.</td>
</tr>
</tbody>
</table>

Table 6  getSamplesTransmission() parameters

The parameters validity ranges are:

- For channelNumber: 1 to TX_CHANNELS.

2.2.1.1.5  Returned value

If an instance is available, the method returns a Transceiver::BasebandSignal::SamplesTransmission* pointer to the service interface for the required Tx channel.

Otherwise, the function returns NULL.

2.2.1.1.6  Originator

Native C++ application component.
2.2.1.1.7 Exceptions

The exceptions (see section 2.2.3) of the method are specified as:

- MaxChannelNumberException,
- UnavailableServiceException.

2.2.1.1.8 Behavior requirements

A native C++ façade needs to, on a call to getSamplesTransmission():

- If no instance of the SamplesTransmission provide service is available:
  - If exceptions are supported, throw UnavailableServiceException,
  - If exceptions are not supported, set the return value to NULL,
- If the SamplesTransmission provide service is available, set the return value with a reference to its service interface,
- Return the call,
- Keep the provide service active at least until the instance of the transceiver implementation has exited the CONFIGURED state.

2.2.2 RxFacade

RxFacade owns the transceiver-specific setSamplesReception() primitive.

2.2.2.1 setSamplesReception method

2.2.2.1.1 Overview

setSamplesReception() passes a pointer used by the façade to reference the instance of SamplesReception implemented by the native C++ application component for the required Rx channel.

2.2.2.1.2 Associated properties

Not applicable.

2.2.2.1.3 Declaration

The C++ signature of the method is specified as:

```cpp
void setSamplesReception(
    Transceiver::BasebandSignal::SamplesReception* reference,
    uint16_t channelNumber);
```
### 2.2.2.1.4 Parameters

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>reference</td>
<td>Transceiver::BasebandSignal::SamplesReception*</td>
<td>Reference of a SamplesReception service interface implemented by the application component.</td>
</tr>
<tr>
<td>channelNumber</td>
<td>uint16_t</td>
<td>Number of the required Rx channel.</td>
</tr>
</tbody>
</table>

Table 7 Specification of `setSamplesReception()` parameters

The parameters validity ranges are:
- For `channelNumber`: 1 to `RX_CHANNELS`.

#### 2.2.2.1.5 Returned value

None.

#### 2.2.2.1.6 Originator

Native C++ application component.

#### 2.2.2.1.7 Exceptions

The exceptions (see section 2.2.3) of the method are specified as:
- MaxChannelNumberException,
- UnavailableServiceException.

#### 2.2.2.1.8 Behavior requirements

A native C++ façade needs to, on a call to a `setSamplesReception()`:
- If no instance of the SamplesReception use service is available:
  - If exceptions are supported, throw UnavailableServiceException.
  - If the SamplesReception use service is available, use reference to set a pointer of the native C++ façade to reference the service interface implemented by the native C++ application component,
- Return the call,
- Use the referenced service interface until the instance of the transceiver exits the CONFIGURED state.

Note: this implies that the SamplesReception use service of the native C++ application component remains valid until the transceiver exits the CONFIGURED state.
2.2.3 Facade exceptions

The exceptions associated to native C++ façades are specified by the following table:

<table>
<thead>
<tr>
<th>Exception</th>
<th>Standard C++ parent</th>
<th>Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>MaxChannelNumberException</td>
<td>std::range_error</td>
<td>The value of channelNumber parameter exceeds TX_CHANNELS or RX_CHANNELS.</td>
</tr>
<tr>
<td>UnavailableServiceException</td>
<td>std::range_error</td>
<td>The accessed service is not available.</td>
</tr>
</tbody>
</table>

Table 8 Façades exceptions
3 Native C++ PSM header files

This normative section specifies the standard C++ header files (.hpp) to be used by conformant (see section 1.2) native C++ transceivers and native C++ application components. Conformant native C++ façades and native C++ application components have only to include XcvrFacades.hpp.

XcvrPlatformProviderAdaptations.hpp captures the adaptations decided by native C++ transceivers implementers.

The supported C++ versions are C++03 and C++11. The standard macro __cplusplus indicates the supported C++ version.

The specified header files have been successfully compiled using:

- GCC 4.8.5 and 7.5.0 for C++ 98, C++ 11, C++14 and C++17.

The used code formatting rules are specified by the Native C++ section of WinInnForum Facilities PSMs Mapping Rules [Ref3].

3.1 <cstdint> (stdint.h)

The <cstdint> (stdint.h) library is used for C++ standard declarations for basic types.

3.2 XcvrFacades.hpp

The XcvrFacades.hpp file is specified as the header file that declares the Facade classes.
The content of `XcvrFacades.hpp` is specified as:

```cpp
#ifndef XCVR_FACADES
#define XCVR_FACADES

#include "XcvrPlatformProviderAdaptations.hpp"
#include "XcvrServices.hpp"

#ifdef EXPLICIT_SERVICES_ACCESS
  #include "XcvrExplicitServicesAccess.hpp"
#endif

#ifdef GENERIC_SERVICES_ACCESS
  #include "XcvrGenericServicesAccess.hpp"
#endif

namespace WInnF_Cpp
{
  namespace Transceiver
  {

    // TxFacade (section 2.2.1 of [PSM])
    class TxFacade
    {
      public:
        #ifdef EXPLICIT_SERVICES_ACCESS
          virtual ActiveServicesAccess::ExplicitServicesAccess *
            getExplicitServicesAccess() NOEXCEPT = 0;
        #endif

        #ifdef GENERIC_SERVICES_ACCESS
          virtual ActiveServicesAccess::GenericServicesAccess *
            getGenericServicesAccess() NOEXCEPT = 0;
        #endif

        virtual void activeServicesInitialized()= 0;
        virtual void activeServicesReleased()= 0;
        virtual void getSamplesTransmission(
          uint16_t channelNumber) NOEXCEPT = 0;
        virtual ~TxFacade() NOEXCEPT {};
    }

    // RxFacade (section 2.2.1 of [PSM])
    class RxFacade
    {
      public:
        #ifdef EXPLICIT_SERVICES_ACCESS
          virtual ActiveServicesAccess::ExplicitServicesAccess *
            getExplicitServicesAccess() NOEXCEPT = 0;
        #endif

        #ifdef GENERIC_SERVICES_ACCESS
          virtual ActiveServicesAccess::GenericServicesAccess *
            getGenericServicesAccess() NOEXCEPT = 0;
        #endif

        virtual void activeServicesInitialized()= 0;
        virtual void activeServicesReleased()= 0;
        virtual void setSamplesReception(
          Transceiver::BasebandSignal::SamplesReception* const reference,
          uint16_t channelNumber) NOEXCEPT = 0;
        virtual ~RxFacade() NOEXCEPT {};
    }
  }
}
```

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3.3 XcvrPlatformProviderAdaptations.hpp

The XcvrPlatformProviderAdaptations.hpp file is specified as the header file specifying all user adaptations:

- *Interface declaration properties*, specified by section 4.5 of the *Transceiver Facility PIM Specification* [Ref1],
- Tx or Rx metadata, if needed,
- Preprocessing variables for *active services access*.

XcvrPlatformProviderAdaptations.hpp has to be used with user adaptations at areas marked with *** PROVIDER-ADAPTATION ***.
The content of `XcvrPlatformProviderAdaptations.hpp` is specified as:

```cpp
// Specifies user-adaptations

#ifndef XCVR_USER_ADAPTATIONS
#define XCVR_USER_ADAPTATIONS

// Active Services Access and Exceptions Support
// *** PROVIDER-ADAPTATION ***
#define EXPLICIT_SERVICES_ACCESS // comment if EXPLICIT is not supported
#define GENERIC_SERVICES_ACCESS  // comment if GENERIC is not supported
#define EXCEPTIONS_SUPPORT     // comment if EXCEPTIONS is not supported

// Interface declaration properties
namespace WInnF_Cpp
{
    namespace Transceiver
    {
        // PIM enumerated identifiers : int16, int32, int64, float32
        // Datatype_prefix for disambiguation vs. <cstdint> types
        enum{ Datatype_int16, Datatype_int32, Datatype_int64, Datatype_float32};

        // *** PROVIDER-ADAPTATION *** CARRIER_FREQ_TYPE value
        const int XCVR_CARRIER_FREQ_TYPE = Datatype_int32; // Specify "Datatype_int32" or "Datatype_int64"

        // *** PROVIDER-ADAPTATION *** DELAY_TYPE value
        const int XCVR_DELAY_TYPE = Datatype_int32; // Specify "Datatype_int32" or "Datatype_int64"

        // *** PROVIDER-ADAPTATION *** IQ_TYPE value
        const int XCVR_IQ_TYPE = Datatype_int32;  // Specify "Datatype_int16", "Datatype_int32" or " Datatype_float32"
    }
}

// TX_META_DATA and RX_META_DATA values
// *** PROVIDER-ADAPTATION *** XCVR_TX_META_DATA value
// #define XCVR_TX_META_DATA FALSE // Uncomment if FALSE
#if XCVR_TX_META_DATA == TRUE
namespace WInnF_Cpp
{
    namespace Transceiver
    {
        typedef struct TxMetaData
        {
            // *** PROVIDER-ADAPTATION ***
            // Specify declaration of Tx metadata fields
        };
    }
#endif // #if XCVR_TX_META_DATA == TRUE
```
3.4 XcvrTypes.hpp

The *XcvrTypes.hpp* file is specified as the header file that declares the *API types* specified by section 3.4 of the *Transceiver Facility PIM Specification* [Ref1].
The content of `XcvrTypes.hpp` is specified as:

```c++
#ifndef XCVR_TYPES
#define XCVR_TYPES

#ifdef __cplusplus

#include <cstdint>

#else
#include <stdint.h>
#endif

#include "XcvrPlatformProviderAdaptations.hpp"

#ifdef __cplusplus

#include <vector>

#endif

// Support of exceptions (section 3.2 of [PIM])
#ifdef EXCEPTIONS_SUPPORT

#include "XcvrExceptions.hpp"
#else

// If exceptions are not supported, make sure NOEXCEPT is defined
#ifdef NOEXCEPT

#else

// If exceptions are not supported, make sure NOEXCEPT is defined

#endif
#endif

namespace WInnF_Cpp
{
    namespace Transceiver
    {
        // Optional types templated declarations
        template<int I> struct OptionalTypes{}
        template<> struct OptionalTypes<Datatype_int16>
        {
            typedef uint16_t IQ;
        };
        template<> struct OptionalTypes<Datatype_int32>
        {
            typedef uint32_t IQ;
            typedef uint32_t Delay;
            typedef uint32_t CarrierFreq;
        };
        template<> struct OptionalTypes<Datatype_int64>
        {
            typedef uint64_t Delay;
            typedef uint64_t CarrierFreq;
        };
        template<> struct OptionalTypes<Datatype_float32>
        {
            typedef float IQ;
        };

        // IQ (section 3.4.11 of [PIM])
        typedef OptionalTypes<XCVR_IQ_TYPE>::IQ IQ;

        // BasebandSample (section 3.4.4 of [PIM])
        struct BasebandSample {IQ valueI; IQ valueQ;};
    }
}
```

```
// BasebandPacket (section 3.4.2 of [PIM])
#if __cplusplus == 199711L  // C++1998/2003
  IDL to C++ mapping of "typedef sequence <BasebandSample>
BasebandPacket;"
#endif // #if __cplusplus == 199711L // C++1998/2003

class BasebandPacket
{
   public:
      BasebandPacket();
      BasebandPacket( uint32_t max);
      BasebandPacket( uint32_t max, uint32_t length, BasebandSample *bbs,
bool release = false);
      ~ BasebandPacket();
      BasebandPacket &operator = (const BasebandPacket &);
      uint32_t maximum() const;
      void length( uint32_t);
      uint32_t length() const;
      BasebandSample &operator [] (uint32_t index);
      const BasebandSample &operator [] (uint32_t index) const;
      bool release() const;
      void replace( uint32_t max, uint32_t length, BasebandSample *bbs, bool
release = false);
      BasebandSample *get_buffer( bool orphan = false);
      const BasebandSample *get_buffer() const;
      static BasebandSample *allocbuff( uint32_t nelems);
      static void freebuff( BasebandSample *);
};
#elif __cplusplus>= 201103L  // C++2011
   typedef std::vector<BasebandSample> BasebandPacket;
@endif // #if __cplusplus == 199711L // C++1998/2003

// BlockLength (section 3.4.3 of [PIM])
typedef uint32_t BlockLength;
const BlockLength UndefinedBlockLength = 0xFFFFFFFF;

// BurstNumber (section 3.4.5 of [PIM])
typedef uint32_t BurstNumber;

// CarrierFreq (section 3.4.6 of [PIM]), in Hz
typedef OptionalTypes<XCVR_CARRIER_FREQ_TYPE>::CarrierFreq CarrierFreq;
#if XCVR_CARRIER_FREQ_TYPE == int32
   const CarrierFreq UndefinedCarrierFreq = 0xFFFFFFFF;
#elif XCVR_CARRIER_FREQ_TYPE == int64
   const CarrierFreq UndefinedCarrierFreq = 0x7FFFFFFFFFFFFFFF;
#else
   #error const XCVR_CARRIER_FREQ_TYPE must be equal to "int32" or "int64"
@endif // #if XCVR_CARRIER_FREQ_TYPE == int32

// Delay (section 3.4.7 of [PIM]), in ns
typedef OptionalTypes<XCVR_DELAY_TYPE>::Delay Delay;
#if XCVR_DELAY_TYPE == int32
   const Delay UndefinedDelay = 0xFFFFFFFF;
#elif XCVR_DELAY_TYPE == int64
   const Delay UndefinedDelay = 0x7FFFFFFFFFFFFFFF;
#else
   #error const XCVR_DELAY_TYPE must be equal to "int32" or "int64"
@endif // #if XCVR_DELAY_TYPE == int32

// Error (section 3.4.8 of [PIM])
#if __cplusplus == 199711L  // C++1998/2003
   enum Error
   {
#elif __cplusplus >= 201103L // C++2011
enum class Error
{
  DelayedTuningError,
  TuningTimeoutError,
  DelayedFirstSampleError,
  FirstSampleTimeoutError,
  TransmissionUnderflowError,
  ReceptionOverflowError,
  ShorterTransmittedBlockError,
  LongerTransmittedBlockError,
  DelayedTuning,
  TuningTimeout,
  DelayedFirstSample,
  FirstSampleTimeout,
  TransmissionUnderflow,
  ReceptionOverflow,
  ShorterTransmittedBlock,
  LongerTransmittedBlock
};

// Event (section 3.4.9 of [PIM])
#if __cplusplus == 199711L // C++1998/2003
enum Event
{
  #elif __cplusplus >= 201103L // C++2011
  enum class Event
  {
    ProcessingStartEvent,
    ProcessingStopEvent,
    SilenceStartEvent,
    SilenceStopEvent
  };

  // Gain (section 3.4.10 of [PIM]), in 1/10 dB
typedef int16_t Gain;
const Gain UndefinedGain = 0xFFFF;

  // MetaData (section 3.4.12 of [PIM])
  // Declared in XcvrUserAdaptations.hpp

  // PacketLength (section 3.4.13 of [PIM])
typedef uint32_t PacketLength;

  // SampleNumber (section 3.4.14 of [PIM])
typedef uint32_t SampleNumber;

  // StrobeSource (section 3.4.15 of [PIM])
enum StrobeSource
  {
    ApplicationStrobe,
    TimeRef_PPS,
    GNSS_PPS,
    UserStrobe1,
    UserStrobe2,
    UserStrobe3,
    UserStrobe4
  };

  // TimeSpec (section 3.4.16 of [PIM])
  struct TimeSpec


```c
{  
    uint32_t seconds;  // in seconds
    uint32_t nanoseconds;
};  // in nanoseconds (<1.000.000.000)
const TimeSpec UndefinedTimeSpec = {0xFFFFFFFF, 0xFFFFFFFF};

// TuningPreset (section 3.4.17 of [PIM])
typedef uint16_t TuningPreset;
const TuningPreset UndefinedTuningPreset = 0xFFFF;
}
#endif  // #ifndef XCVR_TYPES
```
3.5 XcvrServices.hpp

The `XcvrServices.hpp` file is specified as the header file that declares the service interfaces specified by section 3.1 of the Transceiver Facility PIM Specification [Ref1].

It declares `XCVR_PIM_VERSION` in accordance with section “Referenced PIM version” of the Native C++ section of WInnForum Facilities PSMs Mapping Rules [Ref3].

The content of `XcvrServices.hpp` is specified as:

```cpp
#ifndef XCVR_SERVICES
#define XCVR_SERVICES

#if __cplusplus < 199711L
    #error C++ version must be C++98/2003 or later
#endif

// XCVR_PIM_VERSION property
#define XCVR_PIM_VERSION 0x020100L // For V2.1.0
#include "XcvrTypes.hpp"

namespace WInnF_Cpp
{
    namespace Transceiver
    {
        namespace Management
        {
            // Management::Reset (section 2.4.1.1 of [PIM])
            class Reset
            {
                public:
                    virtual void reset() = 0;
                    virtual ~Reset() NOEXCEPT {};
            };

            // Management::RadioSilence (section 2.4.1.2 of [PIM])
            class RadioSilence
            {
                public:
                    virtual void startRadioSilence() = 0;
                    virtual void stopRadioSilence() = 0;
                    virtual ~RadioSilence() NOEXCEPT {};
            };
        } // namespace Management

        namespace BurstControl
        {
            // BurstControl::DirectCreation (section 2.4.2.1 of [PIM])
            class DirectCreation
            {
                public:
                    virtual void startBurst(
                        BlockLength requestedLength) = 0;
                    virtual ~DirectCreation() NOEXCEPT {};
            };

            // BurstControl::RelativeCreation (section 2.4.2.2 of [PIM])
            class RelativeCreation
            {
                public:
                    virtual void scheduleRelativeBurst(
```
bool requestedAlternate,
    Delay requestedDelay,
    BlockLength requestedLength) = 0;
    virtual ~RelativeCreation() NOEXCEPT {} 
};

// BurstControl::AbsoluteCreation (section 2.4.2.3 of [PIM])
class AbsoluteCreation
{
    public:
        virtual void scheduleAbsoluteBurst(
            TimeSpec requestedStartTime,
            BlockLength requestedLength) = 0;
        virtual ~AbsoluteCreation() NOEXCEPT {} 
};

// BurstControl::StrobedCreation (section 2.4.2.4 of [PIM])
class StrobedCreation
{
    public:
        virtual void scheduleStrobedBurst( 
            StrobeSource requestedStrobeSource,
            Delay requestedDelay,
            BlockLength requestedLength) = 0;
        virtual ~StrobedCreation() NOEXCEPT {} 
};

// BurstControl::Termination (section 2.4.2.5 of [PIM])
class Termination
{
    public:
        virtual void setBlockLength( 
            BlockLength requestedLength) = 0;
        virtual void stopBurst() = 0;
        virtual ~Termination() NOEXCEPT {} 
};
}

namespace BasebandSignal
{
    // BasebandSignal::SamplesReception (section 2.4.3.1 of [PIM])
class SamplesReception
{
    public:
        #if XCVR_RX_META_DATA == TRUE
            virtual void pushRxPacket( 
                BasebandPacket rxPacket,
                bool endOfBlock,
                RxMetaData rxMetaData) = 0;
        #else
            virtual void pushRxPacket( 
                BasebandPacket rxPacket,
                bool endOfBlock) = 0;
        #endif // #if XCVR_TX_META_DATA == TRUE
        virtual ~SamplesReception() NOEXCEPT {} 
};
// BasebandSignal::SamplesTransmission (section 2.4.3.2 of [PIM])
class SamplesTransmission
{
    public:
        #if TX_META_DATA == TRUE
            virtual void pushTxPacket(
                BasebandPacket txPacket,
                bool endOfBlock,
                TxMetaData txMetaData) = 0;
        #else
            virtual void pushTxPacket(
                BasebandPacket txPacket,
                bool endOfBlock) = 0;
        #endif // #if TX_META_DATA == TRUE
        virtual ~SamplesTransmission() NOEXCEPT {};
};

// BasebandSignal::RxPacketsLengthControl (section 2.4.3.3 of [PIM])
class RxPacketsLengthControl
{
    public:
        virtual void setRxPacketsLength(
            PacketLength requestedLength) = 0;
        virtual ~RxPacketsLengthControl() NOEXCEPT {};
};

namespace Tuning
{
    // Tuning::InitialTuning (section 2.4.4.1 of [PIM])
class InitialTuning
    {
        public:
            virtual void setTuning(
                TuningPreset requestedPreset,
                CarrierFreq requestedFrequency,
                Gain requestedGain,
                BurstNumber requestedBurstNumber) = 0;
            virtual ~InitialTuning() NOEXCEPT {};
    };

    // Tuning::Retuning (section 2.4.4.2 of [PIM])
class Retuning
    {
        public:
            virtual void retune(
                CarrierFreq requestedFrequency,
                Gain requestedGain,
                Delay requestedDelay) = 0;
            virtual ~Retuning() NOEXCEPT {};
    };
}
namespace Notifications
{
    // Notifications::Events (section 2.4.5.1 of [PIM])
    class Events
    {
        public:
            virtual void notifyEvent(
                Event notifiedEvent) = 0;
            virtual ~Events() NOEXCEPT {});
    }

    // Notifications::Errors (section 2.4.5.2 of [PIM])
    class Errors
    {
        public:
            virtual void notifyError(
                Error notifiedError) = 0;
            virtual ~Errors() NOEXCEPT {});
    }
}

namespace GainControl
{
    // GainControl::GainChanges (section 2.4.6.1 of [PIM])
    class GainChanges
    {
        public:
            virtual void indicateGain(
                Gain newGain,
                SampleNumber firstValidSample) = 0;
            virtual ~GainChanges() NOEXCEPT {});
    }

    // GainControl::GainLocking (section 2.4.6.2 of [PIM])
    class GainLocking
    {
        public:
            virtual void lockGain() = 0;
            virtual void unlockGain() = 0;
            virtual ~GainLocking() NOEXCEPT {});
    }
}

namespace TransceiverTime
{
    // TransceiverTime::TimeAccess (section 2.4.7.1 of [PIM])
    class TimeAccess
    {
        public:
            virtual void getCurrentTime(
                TimeSpec* currentTime) const = 0;
            virtual void getLastStartTime(
                TimeSpec* lastStartTime,
                BurstNumber* lastBurstNumber) const = 0;
            virtual ~TimeAccess() NOEXCEPT {});
    }
}
namespace Strobing
{
    // Strobing::ApplicationStrobe (section 2.4.8.1 of [PIM])
    class ApplicationStrobe
    {
    public:
        virtual void triggerStrobe(void);
        virtual ~ApplicationStrobe() NOEXCEPT {};
    };
}

#ifndef XCVR_SERVICES
#endif // ifndef XCVR_SERVICES

3.6 XcvrExplicitServicesAccess.hpp

The content of XcvrExplicitServicesAccess.hpp is specified as:

#ifndef XCVR_EXPLICIT_SERVICES_ACCESS
#define XCVR_EXPLICIT_SERVICES_ACCESS

namespace WInnF_Cpp
{
    namespace Transceiver
    {
        namespace ActiveServicesAccess
        {
            // Access to specific active services
            class ExplicitServicesAccess
            {
                public:
                    // Provide services
                    // Management services group
                    virtual Transceiver::Management::Reset* getReset() = 0;
                    virtual Transceiver::Management::RadioSilence* getRadioSilence() = 0;
                    // BurstControl services group
                    virtual Transceiver::BurstControl::DirectCreation* getDirectCreation() = 0;
                    virtual Transceiver::BurstControl::RelativeCreation* getRelativeCreation() = 0;
                    virtual Transceiver::BurstControl::AbsoluteCreation* getAbsoluteCreation() = 0;
                    virtual Transceiver::BurstControl::StrobedCreation* getStrobedCreation() = 0;
                    virtual Transceiver::BurstControl::Termination* getTermination() = 0;
                    // BasebandSignal services group
                    virtual Transceiver::BasebandSignal::RxPacketsLengthControl* getRxPacketsLengthControl() = 0;
                    // Tuning services group
                    virtual Transceiver::Tuning::InitialTuning* getInitialTuning() = 0;
                    virtual Transceiver::Tuning::Retuning* getRetuning() = 0;
                    // GainControl services group
                    virtual Transceiver::GainControl::GainLocking* getGainLocking() = 0;
        }
    }
}
#endif // define XCVR_EXPLICIT_SERVICES_ACCESS
// Strobing services group
virtual Transceiver::Strobing::ApplicationStrobe*
getApplicationStrobe() = 0;

// Use services
// Notifications services group
virtual void setEvents( Transceiver::Notifications::Events*
reference) = 0;
virtual void setErrors( Transceiver::Notifications::Errors*
reference) = 0;

// GainControl services group
virtual void setGainChanges( Transceiver::GainControl::GainChanges*
reference) = 0;

virtual ~ExplicitServicesAccess() NOEXCEPT {});
} // namespace ActiveServicesAccess
} // namespace Transceiver
} // namespace WInnF_Cpp
#endif // ifndef XCVR_EXPLICIT_SERVICES_ACCESS

3.7 XcvrGenericServicesAccess.hpp

The content of **XcvrGenericServicesAccess.hpp** is specified as:

```cpp
#ifndef XCVR_GENERIC_SERVICES_ACCESS
#define XCVR_GENERIC_SERVICES_ACCESS

#include "XcvrTypes.hpp"

namespace WInnF_Cpp
{
    namespace Transceiver
    {
        namespace ActiveServicesAccess
        {
            class Object
            {
                public:
                    virtual ~Object() NOEXCEPT {};
            }

            class GenericServicesAccess
            {
                public:
                // Access to active provide services
                    virtual Object *getProvideService(
                        const char *ServiceName) = 0;
                // Access to active use services
                    virtual void setUseService(const char *ServiceName,
                        Object * provider) = 0;
                    virtual ~GenericServicesAccess() NOEXCEPT {};
            } // namespace ActiveServicesAccess
        } // namespace Transceiver
    } // namespace WInnF_Cpp
#endif // ifndef XCVR_GENERIC_SERVICES_ACCESS
```
3.8 XcvrExceptions.hpp

The **XcvrExceptions.hpp** file is specified as the header file that declares all useable exceptions. **XcvrExceptions.hpp** is used if EXCEPTION_USE is equal to true.

The content of **XcvrExceptions.hpp** is specified as:

```cpp
#ifndef XCVR_EXCEPTIONS
#define XCVR_EXCEPTIONS

#include <stdexcept>
#ifndef NOEXCEPT
#if __cplusplus < 201103L
#define NOEXCEPT
#else
#define NOEXCEPT noexcept
#endif
#endif

// Exceptions identifiers (section 3.1.19 of [PIM])
namespace WInnF_Cpp
{
    namespace Transceiver
    {
        // General exceptions
        class NoAlternateReferencingException: public std::invalid_argument
        {
            public:
            NoAlternateReferencingException (char const *msg = "") NOEXCEPT
                : ::std::invalid_argument(msg)
            {
            }
            NoAlternateReferencingException(::std::string const &msg) NOEXCEPT
                : ::std::invalid_argument(msg)
            {
            }
        };
        class NoOngoingProcessingException: public std::runtime_error
        {
            public:
            NoOngoingProcessingException(char const *msg = "") NOEXCEPT
                : ::std::runtime_error(msg)
            {
            }
            NoOngoingProcessingException(::std::string const &msg) NOEXCEPT
                : ::std::runtime_error(msg)
            {
            }
        };
        class StrobeSourceException: public std::invalid_argument
        {
            public:
            StrobeSourceException(char const *msg = "") NOEXCEPT
                : ::std::invalid_argument(msg)
            {
            }
            StrobeSourceException(::std::string const &msg) NOEXCEPT
                : ::std::invalid_argument(msg)
            {
            }
        };
    }
}
#endif
```
// Range exceptions
class MinBlockLengthException: public std::range_error
{
    public:
    MinBlockLengthException(char const *msg = "") NOEXCEPT
        : ::std::range_error(msg)
    {
    }
    MinBlockLengthException(::std::string const &msg) NOEXCEPT
        : ::std::range_error(msg)
    {
    }
};

class MaxBlockLengthException : public std::range_error
{
    public:
    MaxBlockLengthException(char const *msg = "") NOEXCEPT
        : ::std::range_error(msg)
    {
    }
    MaxBlockLengthException(::std::string const &msg) NOEXCEPT
        : ::std::range_error(msg)
    {
    }
};

class MinCarrierFreqException : public std::range_error
{
    public:
    MinCarrierFreqException(char const *msg = "") NOEXCEPT
        : ::std::range_error(msg)
    {
    }
    MinCarrierFreqException(::std::string const &msg) NOEXCEPT
        : ::std::range_error(msg)
    {
    }
};

class MaxCarrierFreqException : public std::range_error
{
    public:
    MaxCarrierFreqException(char const *msg = "") NOEXCEPT
        : ::std::range_error(msg)
    {
    }
    MaxCarrierFreqException(::std::string const &msg) NOEXCEPT
        : ::std::range_error(msg)
    {
    }
};

class MinFromOngoingException: public std::range_error
{
    public:
    MinFromOngoingException(char const *msg = "") NOEXCEPT
        : ::std::range_error(msg)
    {
    }
}
MinFromOngoingException(::std::string const &msg) NOEXCEPT
: ::std::range_error(msg)
{
}
};

class MaxFromOngoingException: public std::range_error
{
public:
MaxFromOngoingException(char const *msg = "") NOEXCEPT
: ::std::range_error(msg)
{
}
MaxFromOngoingException(::std::string const &msg) NOEXCEPT
: ::std::range_error(msg)
{
}
};

class MinFromPreviousException: public std::range_error
{
public:
MinFromPreviousException(char const *msg = "") NOEXCEPT
: ::std::range_error(msg)
{
}
MinFromPreviousException(::std::string const &msg) NOEXCEPT
: ::std::range_error(msg)
{
}
};

class MaxFromPreviousException: public std::range_error
{
public:
MaxFromPreviousException(char const *msg = "") NOEXCEPT
: ::std::range_error(msg)
{
}
MaxFromPreviousException(::std::string const &msg) NOEXCEPT
: ::std::range_error(msg)
{
}
};

class MinFromStrobeException: public std::range_error
{
public:
MinFromStrobeException(char const *msg = "") NOEXCEPT
: ::std::range_error(msg)
{
}
MinFromStrobeException(::std::string const &msg) NOEXCEPT
: ::std::range_error(msg)
{
}
};

class MaxFromStrobeException: public std::range_error
{
public:
MaxFromStrobeException(char const *msg = "") NOEXCEPT
: ::std::range_error(msg)
{
}
MaxFromStrobeException(::std::string const &msg) NOEXCEPT
  : ::std::range_error(msg)
{
}
};

class MinGainException: public std::range_error
{
public:
  MinGainException(char const *msg = "") NOEXCEPT
    : ::std::range_error(msg)
  {
  }
  MinGainException(::std::string const &msg) NOEXCEPT
    : ::std::range_error(msg)
  {
  }
};

class MaxGainException: public std::range_error
{
public:
  MaxGainException(char const *msg = "") NOEXCEPT
    : ::std::range_error(msg)
  {
  }
  MaxGainException(::std::string const &msg) NOEXCEPT
    : ::std::range_error(msg)
  {
  }
};

class MaxNanoSecondsException: public std::range_error
{
public:
  MaxNanoSecondsException(char const *msg = "") NOEXCEPT
    : ::std::range_error(msg)
  {
  }
  MaxNanoSecondsException(::std::string const &msg) NOEXCEPT
    : ::std::range_error(msg)
  {
  }
};

class MaxRxPacketsLengthException: public std::range_error
{
public:
  MaxRxPacketsLengthException(char const *msg = "") NOEXCEPT
    : ::std::range_error(msg)
  {
  }
  MaxRxPacketsLengthException(::std::string const &msg) NOEXCEPT
    : ::std::range_error(msg)
  {
  }
};

class MaxTuningPresetException: public std::range_error
{
public:
  MaxTuningPresetException(char const *msg = "") NOEXCEPT
    : ::std::range_error(msg)
  {
  }
};
// MILT exceptions
class AbsoluteMILTException: public std::runtime_error
{
public:
    AbsoluteMILTException(char const *msg = "") NOEXCEPT
    : ::std::runtime_error(msg)
    {
    }
    AbsoluteMILTException(::std::string const &msg) NOEXCEPT
    : ::std::runtime_error(msg)
    {
    }
};

class RelativeMILTException: public std::runtime_error
{
public:
    RelativeMILTException(char const *msg = "") NOEXCEPT
    : ::std::runtime_error(msg)
    {
    }
    RelativeMILTException(::std::string const &msg) NOEXCEPT
    : ::std::runtime_error(msg)
    {
    }
};

class RetuningMILTException: public std::runtime_error
{
public:
    RetuningMILTException(char const *msg = "") NOEXCEPT
    : ::std::runtime_error(msg)
    {
    }
    RetuningMILTException(::std::string const &msg) NOEXCEPT
    : ::std::runtime_error(msg)
    {
    }
};

class Tuning_MILTException: public std::runtime_error
{ 
    public:
    Tuning_MILTException(char const *msg = "") NOEXCEPT
    : ::std::runtime_error(msg) 
    {
    }
    Tuning_MILTException(::std::string const &msg) NOEXCEPT
    : ::std::runtime_error(msg) 
    {
    }
};

class TxPacketsMILTException: public std::runtime_error
{
    public:
    TxPacketsMILTException(char const *msg = "") NOEXCEPT
    : ::std::runtime_error(msg) 
    {
    }
    TxPacketsMILTException(::std::string const &msg) NOEXCEPT
    : ::std::runtime_error(msg) 
    {
    }
};

// Services access exceptions

class AlreadyConfiguredException: public std::runtime_error
{
    public:
    AlreadyConfiguredException(char const *msg = "") NOEXCEPT
    : ::std::runtime_error(msg) 
    {
    }
    AlreadyConfiguredException(::std::string const &msg) NOEXCEPT
    : ::std::runtime_error(msg) 
    {
    }
};

class MaxChannelNumberException: public std::range_error
{
    public:
    MaxChannelNumberException(char const *msg = "") NOEXCEPT
    : ::std::range_error(msg) 
    {
    }
    MaxChannelNumberException(::std::string const &msg) NOEXCEPT
    : ::std::range_error(msg) 
    {
    }
};

class UnavailableServiceException : public std::runtime_error
{
    public:
    UnavailableServiceException(char const *msg = "") NOEXCEPT
    : ::std::runtime_error(msg) 
    {
    }
    UnavailableServiceException(::std::string const &msg) NOEXCEPT
    : ::std::runtime_error(msg) 
    {
    }
class InvalidReferenceException : public std::runtime_error
{
    public:
    InvalidReferenceException(char const *msg = "") NOEXCEPT
        : ::std::runtime_error(msg)
    {
    }
    InvalidReferenceException(::std::string const &msg) NOEXCEPT
        : ::std::runtime_error(msg)
    {
    }
};
} // namespace Transceiver
} // namespace WInnF_Cpp

#endif // ifndef XCVR_EXCEPTIONS
4 References

4.1 Referenced documents

  https://sds.wirelessinnovation.org/specifications-and-recommendations
  https://winnf.memberclicks.net/assets/work_products/Specifications/WINNF-TS-0008-V2.1.1.pdf

  https://sds.wirelessinnovation.org/specifications-and-recommendations

  https://sds.wirelessinnovation.org/specifications-and-recommendations
  https://winnf.memberclicks.net/assets/work_products/Reports/WINNF-TR-2008-V1.0.1.pdf

  http://www.cplusplus.com/

  http://www.cplusplus.com/

The URLs above were successfully accessed at release date.
END OF THE DOCUMENT