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1 Signal Types

TiA defines the following signals types.

<table>
<thead>
<tr>
<th>Identifier (string)</th>
<th>Value (hex)</th>
<th>Value (dec)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>eeg</td>
<td>0x00000001</td>
<td>1</td>
<td>Electroencephalogram</td>
</tr>
<tr>
<td>emg</td>
<td>0x00000002</td>
<td>2</td>
<td>Electromyogram</td>
</tr>
<tr>
<td>eog</td>
<td>0x00000004</td>
<td>4</td>
<td>Electrooculogram</td>
</tr>
<tr>
<td>ecg</td>
<td>0x00000008</td>
<td>8</td>
<td>Electrocardiogram</td>
</tr>
<tr>
<td>hr</td>
<td>0x00000010</td>
<td>16</td>
<td>Heart rate</td>
</tr>
<tr>
<td>bp</td>
<td>0x00000020</td>
<td>32</td>
<td>Blood pressure</td>
</tr>
<tr>
<td>button</td>
<td>0x00000040</td>
<td>64</td>
<td>Buttons (aperiodic)</td>
</tr>
<tr>
<td>joystick</td>
<td>0x00000080</td>
<td>128</td>
<td>Joystick axis (aperiodic)</td>
</tr>
<tr>
<td>sensors</td>
<td>0x00000100</td>
<td>256</td>
<td>Sensor</td>
</tr>
<tr>
<td>nirs</td>
<td>0x00000200</td>
<td>512</td>
<td>NIRS</td>
</tr>
<tr>
<td>fmri</td>
<td>0x00000400</td>
<td>1,024</td>
<td>FMRI</td>
</tr>
<tr>
<td>mouse</td>
<td>0x00000800</td>
<td>2,048</td>
<td>Mouse axis (aperiodic)</td>
</tr>
<tr>
<td>mouse-button</td>
<td>0x00001000</td>
<td>4,096</td>
<td>Mouse buttons (aperiodic)</td>
</tr>
<tr>
<td>not used yet</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>user_1</td>
<td>0x00010000</td>
<td>65,536</td>
<td>User 1</td>
</tr>
<tr>
<td>user_2</td>
<td>0x00020000</td>
<td>131,072</td>
<td>User 2</td>
</tr>
<tr>
<td>user_3</td>
<td>0x00040000</td>
<td>262,144</td>
<td>User 3</td>
</tr>
<tr>
<td>user_4</td>
<td>0x00080000</td>
<td>524,288</td>
<td>User 4</td>
</tr>
<tr>
<td>undefined</td>
<td>0x00100000</td>
<td>1,048,576</td>
<td>undefined signal type</td>
</tr>
<tr>
<td>event</td>
<td>0x00200000</td>
<td>2,097,152</td>
<td>event</td>
</tr>
</tbody>
</table>

1.1 Aperiodic Signals

Aperiodic signals are signals which are not transmitted at constant time rates. For example the state of joystick axis.

Therefore values of the current state of these signals have be transmitted only if they have changed.

2 Control Connection

A TiA server has to provide a TCP port on which clients can create a control connection. Each client gets its own control connection to the server.

The control connection can be used by the clients to send requests to the server such as “start/stop data transmission”.

Some important remarks:

1. The protocol is in the style of HTTP (line structured text messages)
2. The messages are encoded in UTF-8
3. The message is split into lines which are terminated by the 0x0A character (also known as \n, “line feed” or <LF>)
4. Some messages contain additional XML-structured content which is UTF-8 encoded
5. All characters are case sensitive!

2.1 Control Message Structure

Each message which is send from the client to the server or vice versa is structured as followed:

1. Version line
2. Command line
3. Optional content description line
4. An empty line
5. Optional xml-structured content

Example:
TiA 1.0
CheckProtocolVersion

Example with additional xml-structured content
TiA 1.0
MetaInfo
Content-Length: 79

<?xml version="1.0" encoding="UTF-8"?><tiaMetaInfo version="1.0"></tiaMetaInfo>

2.2 Reply Messages

Each command message is answered with a reply message which contains either an OK or an Error. Error messages optionally contain an error description.

OK message:
TiA 1.0
OK

Error message without an error description:
TiA 1.0
Error

Error message including an error description:
TiA 1.0
Error
Content-Length: 73

<?xml version="1.0" encoding="UTF-8"?><tiaError version="1.0" description="Human readable error description."/>

2.3 Server Commands

A TiA 1.0 server implementation has to support the following commands:

- Check protocol version
- Get metainfo
- Get data connection
- Start data transmission
- Stop data transmission
- Get server state connection
**Check Protocol Version**

This command may be used by the client to check if the server understands the commands the client wants to send. The server has to respond with an OK message if it understands commands of the given protocol version.

Representation:

```
TiA 1.0
CheckProtocolVersion
```

Server responses either with an OK or an error message.

**Get MetaInfo**

This command is used to get the informations about the signals from the server.

Representation:

```
TiA 1.0
GetMetaInfo
```

Server response:

```
TiA 1.0
MetaInfo
Content-Length: [Length of XML Content in Bytes]

<?xml version="1.0" encoding="UTF-8"?><tiaMetaInfo version="1.0">....</tiaMetaInfo>
```

or an error message.

**Get Data Transmission**

Two types of data transmissions exist: “TCP” and “UDP”.

Representation:

```
TiA 1.0 
GetDataConnection: TCP 
```

or

```
TiA 1.0 
GetDataConnection: UDP 
```

Server Response:

```
TiA 1.0 
DataConnectionPort: [Port-Number] 
```

or an error message.

**Start Data Transmission**

Representation:
Server responses either with an OK or an error message.

Stop Data Transmission

Representation:

```plaintext
TiA 1.0
StopDataTransmission
```

Server responses either with an OK or an error message.

Get Server State Connection

Representation:

```plaintext
TiA 1.0
GetServerStateConnection
```

Server Response:

```plaintext
TiA 1.0
ServerStateConnectionPort: [Port-Number]
```

or an error message.

2.4 TiA Meta Info

The TiA meta info is structured in XML and contains information about the signals and the subject.

2.5 TiA Error Description

An error message in TiA version 1.0 optionally supports an error description in a human readable format. No error codes with special meaning are supported in this version.

3 Server State Connection

Additionally to the control- and data-connection a client may request a so called “server state connection”. This connection is used by the server to transmit messages about its state to the clients.

3.1 State Messages

- Server running
- Server shut down
**Server Running**

Just to indicate that the server is running.

TiA 1.0
ServerStateRunning

Clients must no reply to this message.

**Server Shut Down**

Indicates that the server will shut down soon. Therefore the control and the data connection will be closed by the server soon.

TiA 1.0
ServerStateShutdown

Clients must not reply to this message.
4 Data Packet

TiA RAW Data Packet Structure:
(with exemplary content)

<table>
<thead>
<tr>
<th>IP Header</th>
<th>UDP or TCP Header</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TiA Data packet header</td>
</tr>
<tr>
<td></td>
<td>EEG ch 1 (s 1)</td>
</tr>
<tr>
<td></td>
<td>EEG ch 4 (s 1)</td>
</tr>
<tr>
<td></td>
<td>EMG ch 1 (s 1)</td>
</tr>
<tr>
<td></td>
<td>EMG ch 1 (s 4)</td>
</tr>
<tr>
<td></td>
<td>EMG ch 2 (s 3)</td>
</tr>
</tbody>
</table>

|               | EEG (blocksize = 1, several channels) |
|               | EMG (blocksize = 4, 2 channels) |
|               | EOG, ECG,... |

<table>
<thead>
<tr>
<th>TiA Data packet header:</th>
</tr>
</thead>
<tbody>
<tr>
<td>uint8 Version</td>
</tr>
<tr>
<td>uint32 Size</td>
</tr>
<tr>
<td>uint32 Flags</td>
</tr>
<tr>
<td>uint64 PacketNr</td>
</tr>
<tr>
<td>uint64 Timestamp</td>
</tr>
<tr>
<td>data</td>
</tr>
<tr>
<td>data</td>
</tr>
<tr>
<td>data</td>
</tr>
<tr>
<td>uint16[] NrChannels</td>
</tr>
<tr>
<td>uint16[] SamplesPerChannel</td>
</tr>
</tbody>
</table>

4.1 Fixed Header

<table>
<thead>
<tr>
<th>Position (Byte)</th>
<th>Length (Byte)</th>
<th>Type</th>
<th>Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>unsigned integer</td>
<td>Datapacket Version has to be 3</td>
</tr>
<tr>
<td>1</td>
<td>4</td>
<td>unsigned integer</td>
<td>Packet size (in bytes), little endian</td>
</tr>
<tr>
<td>5</td>
<td>4</td>
<td>unsigned integer</td>
<td>Signal type flags</td>
</tr>
<tr>
<td>9</td>
<td>8</td>
<td>unsigned integer</td>
<td>Packet id</td>
</tr>
<tr>
<td>17</td>
<td>8</td>
<td>unsigned integer</td>
<td>Connection packet number</td>
</tr>
<tr>
<td>25</td>
<td>8</td>
<td>unsigned integer</td>
<td>Time stamp</td>
</tr>
</tbody>
</table>

Byte Order

All data and fields are transmitted in little endian.

Packet Size

The packet size is the total number of bytes (octets) of a datapacket including the fixed header, the variable header and the data.

The packet size of an empty datapacket is 33.

Time Stamp

microseconds since server start
4.2 Variable Header

Remarks:

- NoS is the number of signals. This number can be determined by counting the flags which are set in the "signal type flags" field of the fixed header.

<table>
<thead>
<tr>
<th>Position (Byte)</th>
<th>Length (Byte)</th>
<th>Type</th>
<th>Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>33</td>
<td>2 * NoS</td>
<td>Array of 16bit unsigned integer</td>
<td>Number of channels</td>
</tr>
<tr>
<td>33 + (2 * NoS)</td>
<td>2 * NoS</td>
<td>Array of 16bit unsigned integer</td>
<td>Block size of signal (number of samples per channel)</td>
</tr>
</tbody>
</table>

4.3 Data

Data starts at the position 33 + (4 * NoS). Sample values are transmitted as a sequence of 32bit floats (IEEE 754). Samples are firstly ordered by their signal type number (Signal Types).

5 Outlook

Future versions of TiA should guarantee downward compatibility. That means all TiA 1.0 commands should be supported by at least all 1.x versions.

5.1 Error Messages

Error messages may contain error codes to automatically interpret the meaning of an error.

5.2 Datapackets

Important remark: Due to downward compatibility no datapacket can become version 10! (as the first byte in datapacket version 2 is “10”).

6 Appendix

6.1 TiA MetaInfo XML Schema

```xml
<?xml version="1.0" encoding="UTF-8"?>
<!--
This is the XML Schema for the meta info XML representation version 1.0 of TOBI Interface A (TiA)

Version 1.0

author: Christoph Eibel
-->
<xsd:schema xmlns:xsd="http://www.w3.org/2001/XMLSchema">
  <xsd:element name="tiaMetaInfo">
    <xsd:complexType>
      <xsd:sequence>
        <!-- subject info -->
        <xsd:element name="subject" minOccurs="0" maxOccurs="1">
```
<xsd:complexType>
  <xsd:attribute name="id" type="xsd:string" use="optional"/>
  <xsd:attribute name="firstName" type="xsd:string" use="optional"/>
  <xsd:attribute name="surname" type="xsd:string" use="optional"/>
  <xsd:attribute name="sex" use="optional">
    <xsd:simpleType>
      <xsd:restriction base="xsd:string">
        <xsd:enumeration value="m"/>
        <xsd:enumeration value="f"/>
      </xsd:restriction>
    </xsd:simpleType>
  </xsd:attribute>
  <xsd:attribute name="birthday" type="xsd:date" use="optional"/>
  <xsd:attribute name="handedness" use="optional">
    <xsd:simpleType>
      <xsd:restriction base="xsd:string">
        <xsd:enumeration value="l"/>
        <xsd:enumeration value="r"/>
      </xsd:restriction>
    </xsd:simpleType>
  </xsd:attribute>
  <xsd:attribute name="medication" type="xsd:boolean" use="optional"/>
  <xsd:attribute name="glasses" type="xsd:boolean" use="optional"/>
  <xsd:attribute name="smoker" type="xsd:boolean" use="optional"/>
</xsd:complexType>

<!-- master signal info -->
<xsd:element name="masterSignal" minOccurs="0" maxOccurs="1">
  <xsd:complexType>
    <xsd:attribute name="samplingRate" type="xsd:float" use="required"/>
    <xsd:attribute name="blockSize" type="xsd:integer" use="required"/>
  </xsd:complexType>
</xsd:element>

<!-- signal info -->
<xsd:element name="signal" minOccurs="0" maxOccurs="unbounded">
  <xsd:complexType>
    <!-- channels -->
    <xsd:sequence>
      <xsd:element name="channel" minOccurs="0" maxOccurs="unbounded">
        <xsd:complexType>
          <xsd:attribute name="nr" type="xsd:nonNegativeInteger" use="required"/>
          <xsd:attribute name="label" type="xsd:string" use="required"/>
        </xsd:complexType>
      </xsd:element>
    </xsd:sequence>
    <!-- signal type: as defined in TiA 1.0 -->
    <xsd:attribute name="type" use="required">
      <xsd:simpleType>
        <xsd:restriction base="xsd:string">
          <xsd:enumeration value="eeg"/>
          <xsd:enumeration value="emg"/>
          <xsd:enumeration value="eog"/>
          <xsd:enumeration value="ecg"/>
          <xsd:enumeration value="hr"/>
          <xsd:enumeration value="bp"/>
          <xsd:enumeration value="buttons"/>
          <xsd:enumeration value="joystick"/>
          <xsd:enumeration value="sensors"/>
        </xsd:restriction>
      </xsd:simpleType>
    </xsd:attribute>
  </xsd:complexType>
</xsd:element>
6.2 TiA MetaInfo XML Example

```xml
<?xml version="1.0" encoding="UTF-8"?>
<tiaMetaInfo version="1.0">
  <subject id="WE2" firstName="Max" lastName="Mustermann" handedness="r" />
  <masterSignal sampleRate="100" blockSize="10" />
  <signal type="eeg" blockSize="10" sampleRate="100" numChannels="3">
    <channel nr="1" label="Cz" />
    <channel nr="2" label="C1" />
    <channel nr="3" label="C2" />
  </signal>
  <signal type="bp" blockSize="5" sampleRate="50" numChannels="5">
    <channel nr="3" label="Channel 3 with Label" />
    <channel nr="2" label="Channel 2 with Label" />
    <!--
        Channel 1, 4 and 5 have no labels
    -->
  </signal>
</tiaMetaInfo>
```

6.3 TiA Error Message XML Schema