Earth–Moon Link Challenges

- Congestion
- Different types of interconnected devices and traffic
- Several networks

Bundle Protocol (BP)

Need for QoS Management

QoS Extension Block to BP
QoS BP Extension Proposal

Primary Bundle Block

Extension Blocks

Payload Block

User QoS Extension Block

Network QoS Extension Block

Traffic Prioritization
Required Reliability
...

Local values

x1

xN

Extension Block Design

User QoS Extension Block (UQEB)

- Canonical Block Extension Info
- CBOR Map
- User Type: User Value
- User Type: User Value

Network QoS Extension Block (NQEB)

- Canonical Block Extension Info
- Inserting Node ID
- CBOR Map
- Network Type: Network Value
- Network Type: Network Value

User QoS Extension Block (UQEB)

- Type Field
  - Traffic Prioritization
  - Required Reliability
  - Latest Only

- Value Field
User QoS Extension Block (UQEB)

Type Field

- Traffic Prioritization
- Required Reliability
- Latest Only

Value Field

<table>
<thead>
<tr>
<th>Information Type</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Critical</td>
<td>0</td>
</tr>
<tr>
<td>Quasi-Real-Time</td>
<td>1 - 12</td>
</tr>
<tr>
<td>Store-and-Forward</td>
<td>13 - 23</td>
</tr>
<tr>
<td>Unassigned</td>
<td>24 - 2^64-1</td>
</tr>
</tbody>
</table>
Traffic Prioritization Workflow

1. Critical
2. Quasi-Real-Time
3. Store-and-Forward

“Quasi-Real-Time” will only be serviced if “Critical” is empty, and “Store-and-Forward” will only be accessed if both “Critical” and “Quasi-Real-Time” are empty.

Weighted queueing is implemented within each type to avoid data starvation.
### User QoS Extension Block (UQEB)

**Type Field**
- Traffic Prioritization
- Required Reliability
- Latest Only

**Value Field**

<table>
<thead>
<tr>
<th>Information Type</th>
<th>Values</th>
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<tbody>
<tr>
<td>Critical</td>
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<td>24 - 2^64-1</td>
</tr>
</tbody>
</table>

---

User QoS Extension Block (UQEB)

**Type Field**
- Traffic Prioritization
- Required Reliability
- Latest Only

**Value Field**

<table>
<thead>
<tr>
<th>Information Type</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reliable</td>
<td></td>
</tr>
<tr>
<td>Strictly reliable</td>
<td>0</td>
</tr>
<tr>
<td>Reliable if possible</td>
<td>1</td>
</tr>
<tr>
<td>Reserved for future use</td>
<td>2 - 11</td>
</tr>
<tr>
<td>Unreliable</td>
<td></td>
</tr>
<tr>
<td>Reserved for future use</td>
<td>12 - 21</td>
</tr>
<tr>
<td>Unreliable if possible</td>
<td>22</td>
</tr>
<tr>
<td>Strictly unreliable</td>
<td>23</td>
</tr>
<tr>
<td>Unassigned</td>
<td>24 - 2^64-1</td>
</tr>
</tbody>
</table>
# User QoS Extension Block (UQEB)

## Type Field

<table>
<thead>
<tr>
<th>Traffic Prioritization</th>
<th>Required Reliability</th>
<th>Latest Only</th>
</tr>
</thead>
</table>

## Value Field

<table>
<thead>
<tr>
<th>Information Type</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>All valid</td>
<td>0</td>
</tr>
<tr>
<td>Latest-only</td>
<td>1</td>
</tr>
<tr>
<td>Reserved for future use</td>
<td>2 - 23</td>
</tr>
<tr>
<td>Unassigned</td>
<td>24 - $2^{64}-1$</td>
</tr>
</tbody>
</table>

Binary flag
Proposal: Example of Execution

- **Bundle number x**
- **D** - Destination
- **N** - Node
- **QRT** - Quasi-Real-Time
- **R** - Reliability
- **Re** - Reliable Transmission
- **S** - Source
- **S&F** - Store-and-Forward
- **TP** - Traffic Priority
- **URe** - Unreliable Transmission
Network QoS Extension Block (NQEB)

- **Type Field**: Local Use
- **Value Field**: Local Use

NQEB could translate UQEB into internal policy and optimize the decision process for the intermediate blocks of a network.

All values are reserved for local use to give the individual networks maximum flexibility.
NQEB Usage Example

\[ \text{G}_{N2} \rightarrow \text{N}_{N2} \rightarrow \text{G}_{N2} \]

- **D**: Destination
- **G**: Gateway
- **Nx**: Network number x
- **NP**: Network Priority
- **N**: Node
- **R**: Reliability
- **S**: Source
- **TP**: Traffic Priority
QoS BP Extension Proposal

Question time!

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Andreas Timm-Giel, Hamburg University of Technology

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Extra Slides
Key and value will always go as a pair, eliminating possible errors

## Proposal: Extension Block Example

<table>
<thead>
<tr>
<th>Type Field</th>
<th>Value</th>
<th>Content</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Priority</td>
<td>1</td>
<td>Best effort</td>
<td>13</td>
</tr>
<tr>
<td>Reliability</td>
<td>2</td>
<td>Unreliable</td>
<td>23</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>

**Canonical Block Extension Info**

- 1:13
- 2:23
UQEB: Traffic Prioritization Justification

Source

Real-Time Comms

Store-and-Forward Comms

Messaging

Destination
## BPv6 Extended Class of Service (ECOS)

The first field of the block data shall be an 8-bit ‘flags’ byte.

1. The 0x01 bit, if ‘True’, shall indicate that the bundle is ‘critical’.
2. The 0x02 bit, if ‘True’, shall indicate that the bundle is ‘streaming’ (best-effort).
3. The 0x04 bit, if ‘True’, shall indicate that the ‘ordinal’ byte of this ECOS block (the byte immediately following the flags byte) is followed by a numeric ‘flow label’ in SDNV representation.
4. The 0x08 bit, if ‘True’, shall indicate that the bundle requires reliable transmission.
5. All other bits of the flags byte are reserved for future use.

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Critical</td>
<td>Streaming</td>
<td>XX</td>
<td>Flow label</td>
<td>XX</td>
<td>XX</td>
<td>XX</td>
</tr>
</tbody>
</table>

Reliable Transmission