Service Discovery and Access in Vehicle-to-Roadside Multi-Channel VANETs

Workshop on Wireless Vehicular Communications
11 November 2015

Claudia Campolo, Antonella Molinaro, Alexey Vinel, Nikita Lyamin, Magnus Jonsson
Service discovery and access in drive-thru scenario
Service discovery and access in drive-thru scenario

- Sparse roadside infrastructure
- High mobility of vehicles

Alexey Vinel @ WWVC 2015
Multi-channel allocation

USA

5.850 5.860 5.870 5.880 5.890 5.900 5.910 5.920

CCH  SCH  SCH  SCH  CCH  SCH  SCH  SCH

Reserved  Future use

Europe

5.860 5.870 5.880 5.890 5.900

SCH4  SCH3  SCH1  SCH2  CCH

ITS-G5B  ITS-G5A

10 MHz
### Channel allocation for dual radio devices

<table>
<thead>
<tr>
<th>Region</th>
<th>Safety Channel</th>
<th>Advertising Channel</th>
<th>Advertised Channel</th>
</tr>
</thead>
<tbody>
<tr>
<td>US</td>
<td>CH 172</td>
<td>CCH</td>
<td>Any SCH (except CH 172)</td>
</tr>
<tr>
<td>Europe</td>
<td>CCH</td>
<td>SCH1 (or SCH3)</td>
<td>SCH2-SCH4</td>
</tr>
</tbody>
</table>

![Diagram showing radio switching](https://via.placeholder.com/150)

**Radio 1**

**Radio 2**

**Switching**

Alexey Vinel @ WWVC 2015
Behavior of the second switching radio interface

\[
\begin{align*}
SCH1 & \quad x \quad p \quad i = 1 \\
SCH2 - SCH4 & \quad i = n = T/\tau \\
\end{align*}
\]

\(T\)  Residence time
\(\tau\)  SAM period
\(x\)  Mean service disruption time
\(p\)  SAM failure probability

Switching time
SAM (ETSI), WSA (IEEE)
Interfering packet
DATA
Service discovery and access: fundamental tradeoff

Reduced Advertised SCH Utilization

Decreased Service Discovery Time

Decreased service discovery time comes at a cost of a reduced advertised channel utilization
Calculation of basic parameters

\[ p = 1 - (1 - BER)^L (1 - p_0) \]
\[ p_0 = 1 - \left( 1 - \frac{2}{W + 1} \right)^N \]
\[ x = B(W) + x_0 + 2T_{sw} \]
\[ x_0 = T_h + \frac{L}{R} + SIFS + AIFS_N \cdot \sigma \]
\[ B(w) = \frac{1}{w} \cdot 0 + (1 - \frac{1}{w}) \cdot \{(1 - p_0)[\sigma + B(w - 1)] + p_0[x_0 + B(w - 1)]\} \]
The mean service discovery time: the expected time that elapses from the moment a vehicle enters the RSU coverage until the moment it successfully receives the SAM.

\[ D(\tau) = \tau \cdot \frac{np^{n+1} - np^n - p^n + 1}{(1 - p)(1 - p^n)} + (x - \tau) \]
Performance metric II

The service channel utilization: fraction of the residence time available for accessing the service – it starts from the successful SAM reception and ends when vehicle goes out of the RSU’s radio range, also excluding service disruption times.

\[
U(\tau) = \frac{x - \tau}{T} \cdot \frac{np^{n+1} - np^n - p^n + 1}{1 - p} + \frac{T - xn - x + \tau}{T} \cdot (1 - p^n)
\]
Mean service discovery time

\[ D(\tau) \text{ [ms]} \]

- \( N=0, T=10s \)
- \( N=5, T=10s \)
- \( N=10, T=10s \)
- \( N=15, T=10s \)
- \( N=0, T=20s \)
- \( N=5, T=20s \)
- \( N=10, T=20s \)
- \( N=15, T=20s \)

\( T \) – residence time
\( N \) – interfering packets on the advertising channel

SAM period: \( \tau \text{ [ms]} \)
Service channel utilization

\[ T - \text{residence time} \]
\[ N - \text{interfering packets on the advertising channel} \]

- \( N=0, T=10s \)
- \( N=5, T=10s \)
- \( N=10, T=10s \)
- \( N=15, T=10s \)
- \( N=0, T=20s \)
- \( N=5, T=20s \)
- \( N=10, T=20s \)
- \( N=15, T=20s \)

SAM period: \( \tau \) [ms]

Alexey Vinel @ WWVC 2015
Conclusions

Providers are recommended to set the SAM period according to the nature of the delivered service:

- SAM periods that privilege higher channel utilization are particularly indicated when the provider and the vehicle should exchange a large amount of data.
- On the other hand, SAM period values that provide shorter discovery time may be required when offering low-latency services and/or when a small amount of data is to be exchanged.
Service Discovery and Access in Vehicle-to-Roadside Multi-Channel VANETs

How I feel going somewhere that has no wifi / DSRC