Petrozavodsk State University
Department of Computer Science

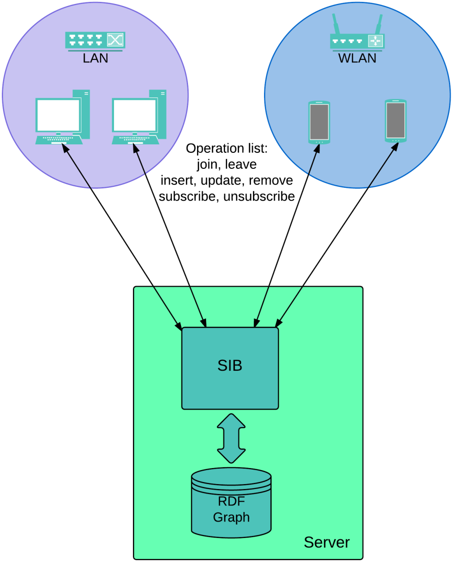
Andrey Vdovenko, Dmitry Korzun

# Mobile Client Control of Notification Check Interval for Subscription in Smart Space

AMICT-2014 conference

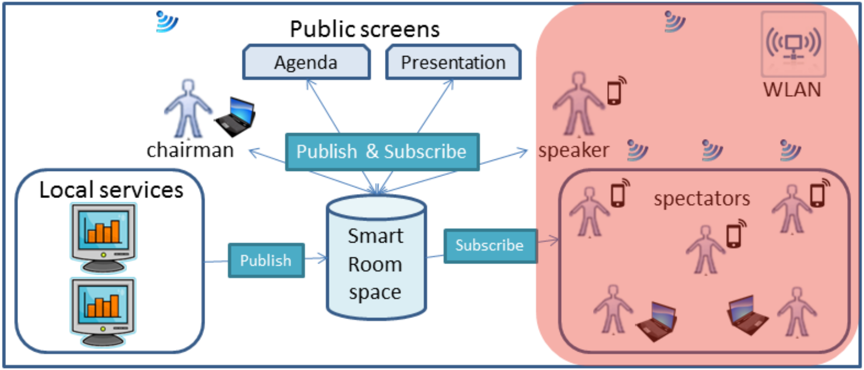
October 22, 2014, Petrozavodsk, Russia

# Smart-M3 Platform




- Implements infrastructure of Smart Spaces for knowledge sharing by agents (M3-agent, knowledge processor, KP)
- SIB: Semantic Information Broker for maintenance of shared content
- RDF data representation model: semantic interoperability and ontology-driven programming

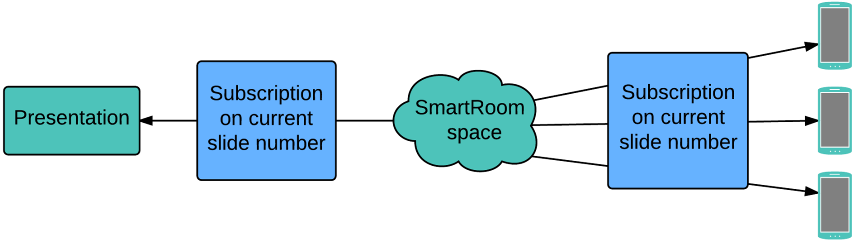
# SmartRoom System




- Many services (composition, personalization)
  - ⇝ informational, control, collaborative work, ...
- Participation of many users (user can be indoor and outdoor)
  - ⇝ Many (mobile) clients running and accessing services
- Users come with own devices
  - ⇝ Many mobile platforms, IoT-like device diversity

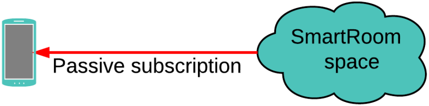
# Publish/subscribe in Smart Spaces

- Subscription process:
  - a publisher produces some informational content
  - subscriber is interested in certain content, then it specifies its interest as a persistent query-subscription
  - a change can affect many subscribers, the specified content can be changed by different publishers
- For Smart-M3:
  - subscription requires its client to establish a network connection
  - changes are controlled on the smart space side
  - the corresponding notifications are sent to the client (passive)

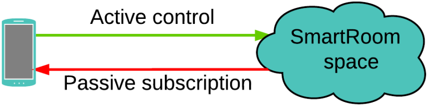


# Delivery guarantee problem

- Subscription's Problems:
  - Broker (SIB) doesn't check delivery for already sent notifications
  - In mobile clients:
    - the subscription is affected by losses of notifications
    - fault tolerance is essentially affected due to the specifics of wireless network communication (Wi-Fi, 3G, etc.)
- Solution:
  - Active control by a mobile client itself for receiving subscription notifications
  - Additional control allows mitigating the consequences of notification losses




Current state



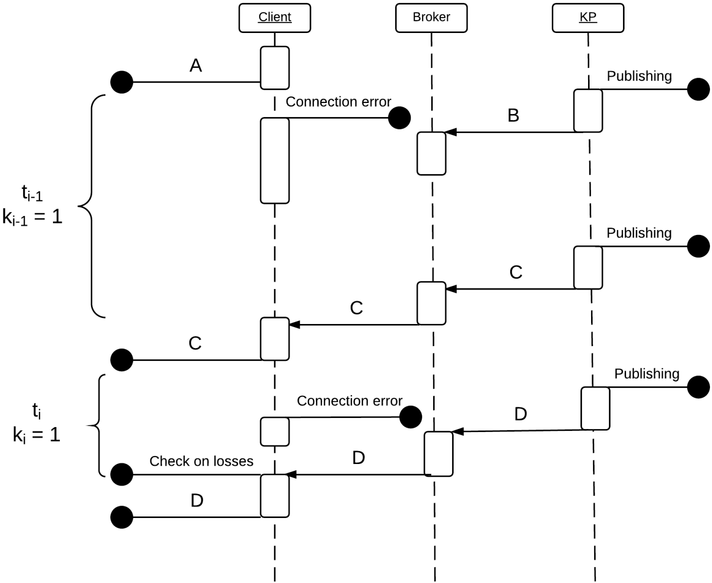

Proposed solution

# Subscription Parameters at the Client Side

The tradeoff of passive and active notifications:

- Notifications arrive sequentially to the client
- $i$ is the sequence number of a notification the client successfully has received by the subscription
- $t_i$ is the time interval between delivered notifications $i - 1$ and $i$
- $k_i$ is the observed number of losses in the interval $t_i$, i.e., between successfully delivered notifications $i - 1$ and $i$
  - In the simplest case, the client can assign $k_i = 1$ if it observes an evident failure
- $\lambda = \lambda_i = k_i / t_i$ is the estimation of instant rate for the notification loss
  - The client is interested in minimizing $\lambda$.

# Subscription process example



# Mathematical Model

- With active notifications, $t_i$ becomes a control variable for the client
- Let the client have observed no losses in $t_{i-1}$, i.e., $k_{i-1} = 0$:

$$t_i = t_{i-1} + \delta \tag{1}$$

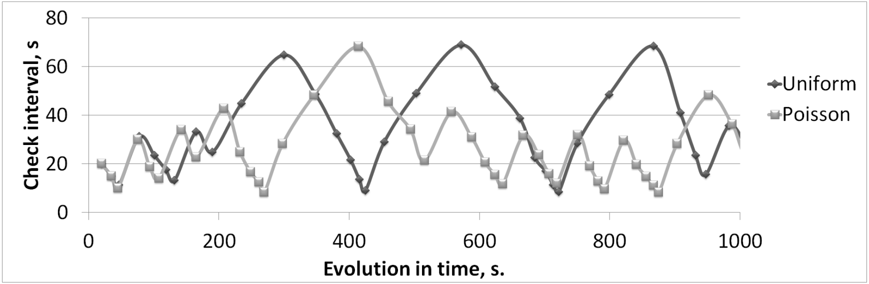
- Let the client have observed certain losses in $t_{i-1}$, i.e., $k_{i-1} > 0$:

$$t_i = \alpha t_{i-1} + (1 - \alpha)\frac{t_{i-1}}{k_{i-1} + 1} \tag{2}$$

- Combining (1) and (2) we construct the recurrent system

$$t_i = \begin{cases} t_{i-1} + \delta & \text{if } k_{i-1} = 0, \\ \dfrac{1 + \alpha k_{i-1}}{k_{i-1} + 1} t_{i-1} & \text{if } k_{i-1} > 0. \end{cases} \tag{3}$$

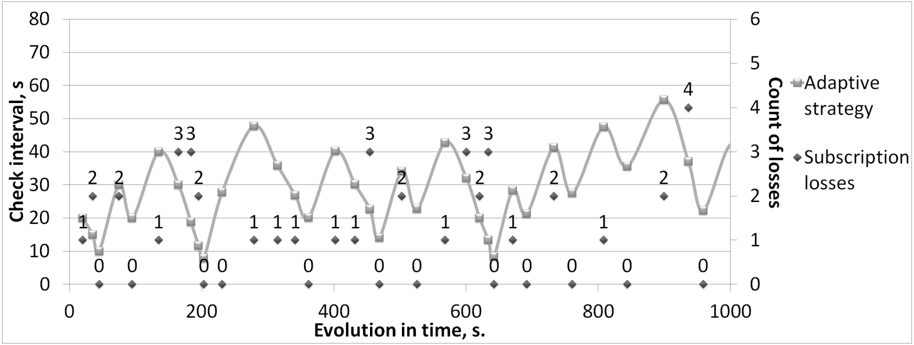
# Simulation Experiments: adaptive strategy




Behaviour of strategy for different distribution of notifications losses:

| Parameter | Value | Description |
|---|---|---|
| **Uniform distribution** | | Value for $k_i$ is selected from $[at_i, bt_i]$ uniformly at random |
| $a$ | 0 | |
| $b$ | 0,1 | |
| **Poisson distribution** | | Value for $k_i$ follows the distribution with mean and variance $\lambda t_i$ for $\lambda > 0$ |
| $\lambda$ | 0,05 | |

# Simulation Experiments: adaptive strategy with losses



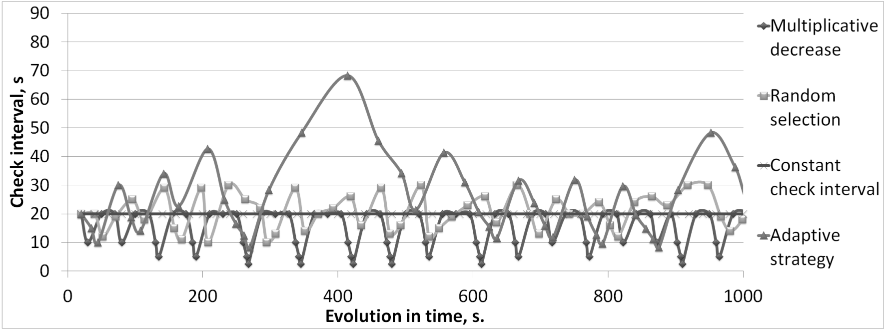

- Shows the count of losses ($k_i$) and the response behavior of the adaptive strategy
- The distribution of losses is Poisson

# Parameters of the experimented strategies

| **Strategy** | | **Description** |
|---|---|---|
| **Parameter** | **Value** | |
| **Adaptive strategy** | | $\alpha = 0.5$ trades off previous and recent observations equally. $\delta = 20$ s is equal to the interval for one loss on average. |
| $\alpha$ | 0.5 | |
| $\delta$ | 20 | |
| **Multiplicative decrease** | | When $k_{i-1} > 0$ the check interval $t_i$ is reduced by 2. If $k_{i-1} = 0$ then set $t_i = t_0$. |
| factor | 0,5 | |
| **Random selection** | | Random strategy when $t_i$ is selected from interval $(a, b)$ at random. |
| $a$ | 10 | |
| $b$ | 30 | |
| **Constant check interval** | | The check interval is always set $t_i = t_0$. |

The initial value is $t_0 = 20s$, which confirms the intuition that one loss happens on this interval on average

# Simulation Experiments: comparison




| Metric | Multiply decrease | Random selection | Constant interval | Adaptive strategy |
|---|---|---|---|---|
| $k_{\text{avg}} = \frac{1}{n}\sum_{i=1}^{n} k_i$ | 0,59 | 1,19 | 0,89 | 1,23 |
| $t_{\text{avg}} = \frac{1}{n}\sum_{i=1}^{n} t_i$ | 14,23 | 19,87 | 20 | 28,8 |
| $\lambda = k_{\text{avg}}/t_{\text{avg}}$ | 0,042 | 0,06 | 0,045 | 0,041 |
| $\lambda_{\text{avg}} = \frac{1}{n}\sum_{i=1}^{n}\frac{k_i}{t_i}$ | 0,078 | 0,06 | 0,045 | 0,043 |

# Variation of $\delta$ in the adaptive strategy

| Parameters | Variation | | | |
|---|---|---|---|---|
| $\delta$ | 10 | 20 | 40 | 60 |
| **Metric** | **Values** | | | |
| $k_{\text{avg}} = \frac{1}{n}\sum_{i=1}^{n} k_i$ | 1,06 | 1,14 | 1,77 | 2,16 |
| $t_{\text{avg}} = \frac{1}{n}\sum_{i=1}^{n} t_i$ | 22,01 | 24,76 | 32,6 | 43,86 |
| $\lambda = k_{\text{avg}}/t_{\text{avg}}$ | 0,048 | 0,046 | 0,054 | 0,049 |
| $\lambda_{\text{avg}} = \frac{1}{n}\sum_{i=1}^{n}\frac{k_i}{t_i}$ | 0,047 | 0,049 | 0,054 | 0,048 |

- Smaller values for $\delta$ leads to less losses
- Bigger values reduce the load the client shifts to the SIB

# Conclusion

- Studied the problem of subscription fault tolerance for the case of a mobile client interacts with other participant in a smart space
  - if the client performs none or rare active checks then it can suffer from losses of some notifications
  - high pooling from the client leads to excessive load
- Proposed a simple mathematical model that aims at achieving a trade-off at the client side when the client adapts its check interval to the current observations of the notification loss
  - Simulation experiments show that the solution is reasonability compared with non-adaptive client strategies
- Start to apply the model in real settings
  - Applying for SmartRoom clients
  - Problem in counting losses