Petrozavodsk State University
Department of Computer Science

cs.karelia.ru

Andrey Vdovenko, Dmitry Korzun

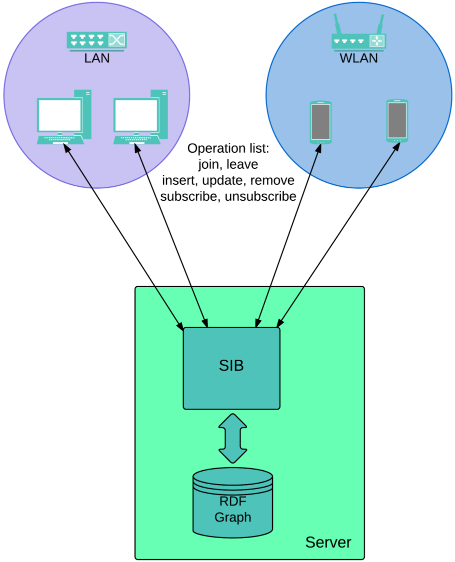
Active Control by a Mobile Client of Subscription Notifications in Smart Space

The work is supported by project # 1481
from the basic part of state research assignment # 2014/154
and by project # 2.2336.2014/K
of the Ministry of Education and Science of the Russian Federation.

16^{th} FRUCT Conference

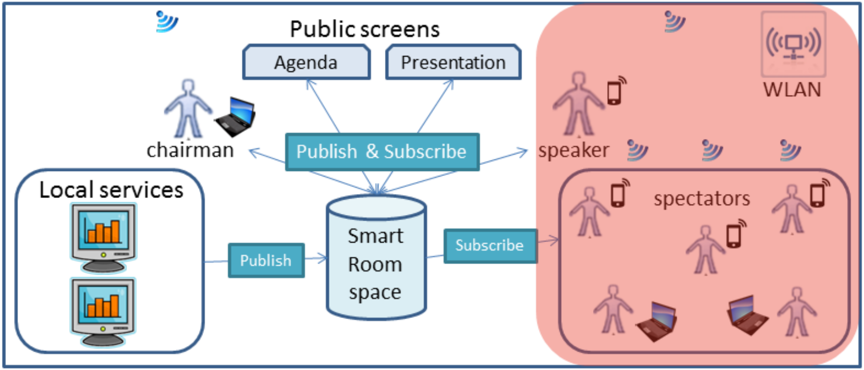
October 30, 2014, Oulu, Finland

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

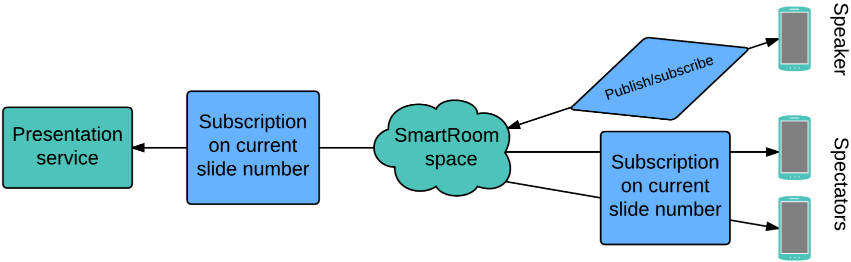
SmartRoom System



- 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

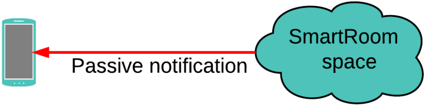
Publish/subscribe in Smart Spaces

- Subscription process:
  - a publisher produces some informational content
  - subscriber is interested in certain content
  - a change can affect many subscribers
  - 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)

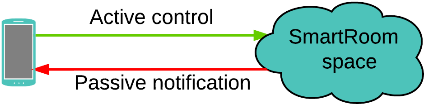


Delivery guarantee problem

- Subscription 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 subscription notifications
  - Additional checks allows mitigate the effects of notification losses



Current state

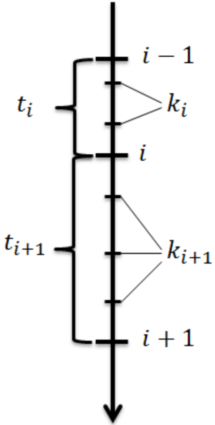


Proposed solution

Subscription Parameters at the Client Side

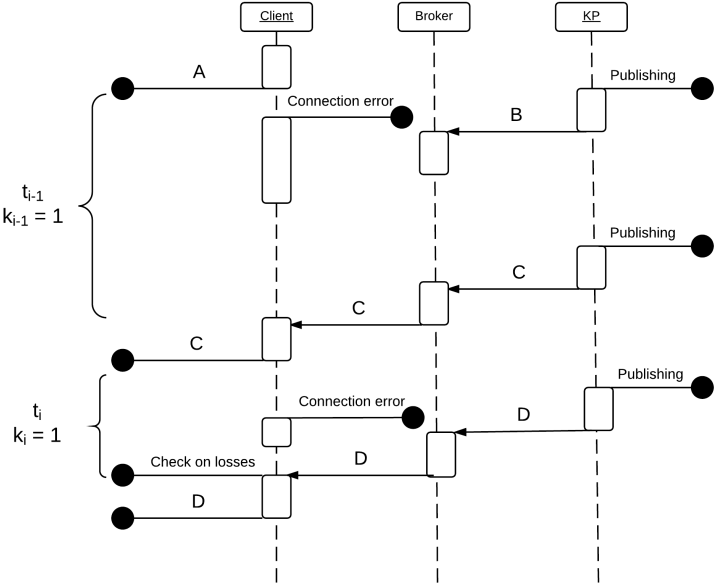
The tradeoff of passive and active notifications:

- Notifications arrive sequentially to the client
- i is the sequence number of a notification
- t_i is the time interval
- k_i is the observed number of losses
- $\lambda = \lambda_i = k_i / t_i$ is the instant rate for the notification loss



$\rightsquigarrow$ The client is interested in minimizing λ.

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

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

Experiments: Adaptive Strategy

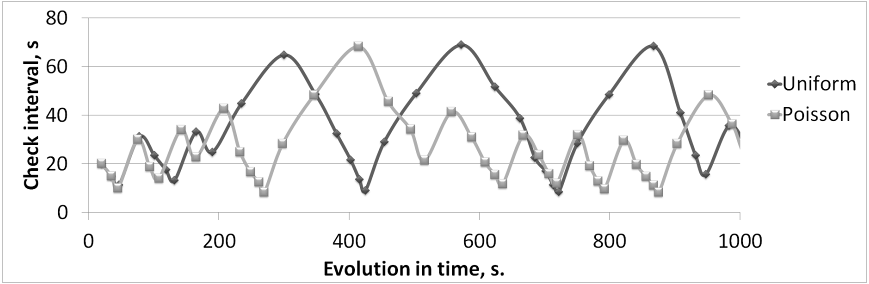
Behaviour of strategy for different distribution of notifications losses:

Parameter	Value	Description
Uniform distribution		$k_i \in [at_i, bt_i]$ uniformly at random
a	0	
b	0.1	
Poisson distribution		k_i $P(\lambda t_i)$ for $\lambda > 0$
λ	0.05	

Our strategy:

$$t_i = \begin{cases} t_{i-1} + \delta \\ \dfrac{1 + \alpha k_{i-1}}{k_{i-1} + 1} t_{i-1} \end{cases}$$

$$\alpha = 0.5, \ \delta = 20$$

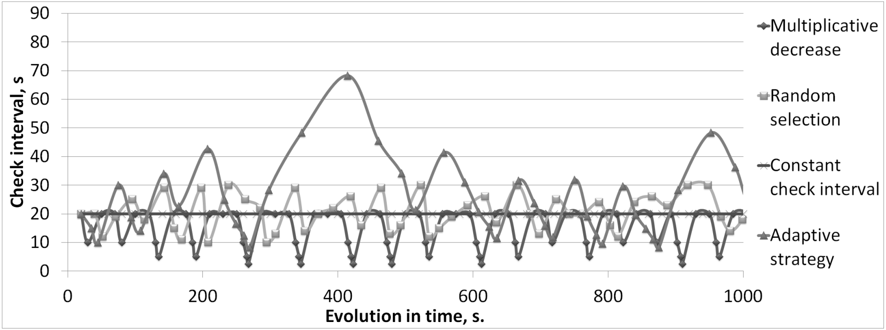


Experiments: Compared Strategies

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.
α	0.5	
δ	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

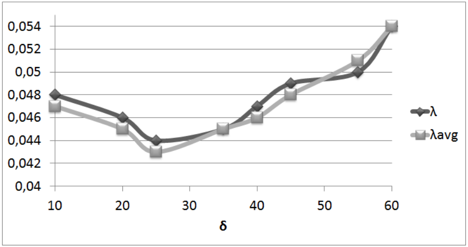
Experiments: Comparison



Metric	Multiply decrease	Random selection	Constant interval	Adaptive strategy
$k_{\text{avg}} = \frac{1}{n}\sum_{i=1}^{n} k_i$ (min)	0.59	1.19	0.89	1.23
$t_{\text{avg}} = \frac{1}{n}\sum_{i=1}^{n} t_i$ (max)	14.23	19.87	20	28.8
$\lambda = k_{\text{avg}}/t_{\text{avg}}$ (min)	0.042	0.06	0.045	0.041
$\lambda_{\text{avg}} = \frac{1}{n}\sum_{i=1}^{n}\frac{k_i}{t_i}$(min)	0.078	0.06	0.045	0.043

Experiments: Variation of δ in the Adaptive Strategy

Parameters	Variation			
δ	10	20	40	60
Metric	**Values**			
$k_{avg} = \frac{1}{n}\sum_{i=1}^{n} k_i$ (min)	1.06	1.14	1.77	2.16
$t_{avg} = \frac{1}{n}\sum_{i=1}^{n} t_i$ (max)	22.01	24.76	32.6	43.86
$\lambda = k_{avg}/t_{avg}$ (min)	0.048	0.046	0.047	0.054
$\lambda_{avg} = \frac{1}{n}\sum_{i=1}^{n} \frac{k_i}{t_i}$ (min)	0.047	0.045	0.046	0.054



- Smaller values for δ leads to less losses
- Bigger values reduce the load the client shifts to the SIB

Conclusion

- Studied the problem of subscription fault tolerance
- Proposed a simple mathematical model for active control
- Start to apply the model in real settings

Thank you for attention

E-mail: vdovenko@cs.karelia.ru