Multilingual Ontology Library Generator for Smart-M3 Application Development

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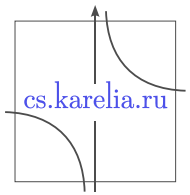
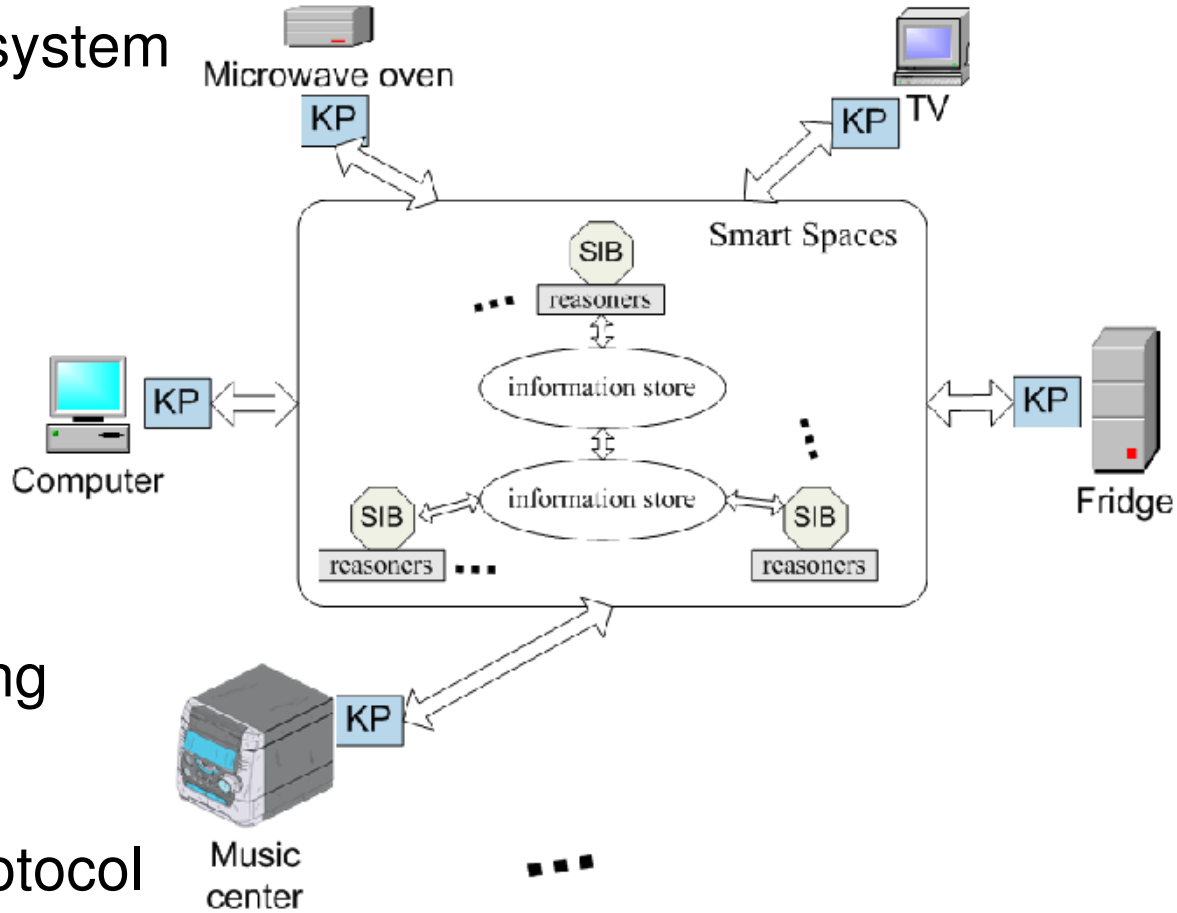


Smart-M3 platform

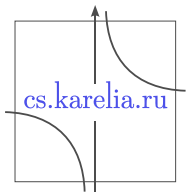
A kind of publish/subscribe system

- Semantic information brokers (SIBs) maintain SS content in low-level RDF triples
- Application consists of several knowledge processors (KPs) running on each device
- Smart space access protocol (SSAP) for SIB↔KP communication
- Smart-M3: **M**ultidomain, **M**ultidevice, **M**ultivendor



KP development tools

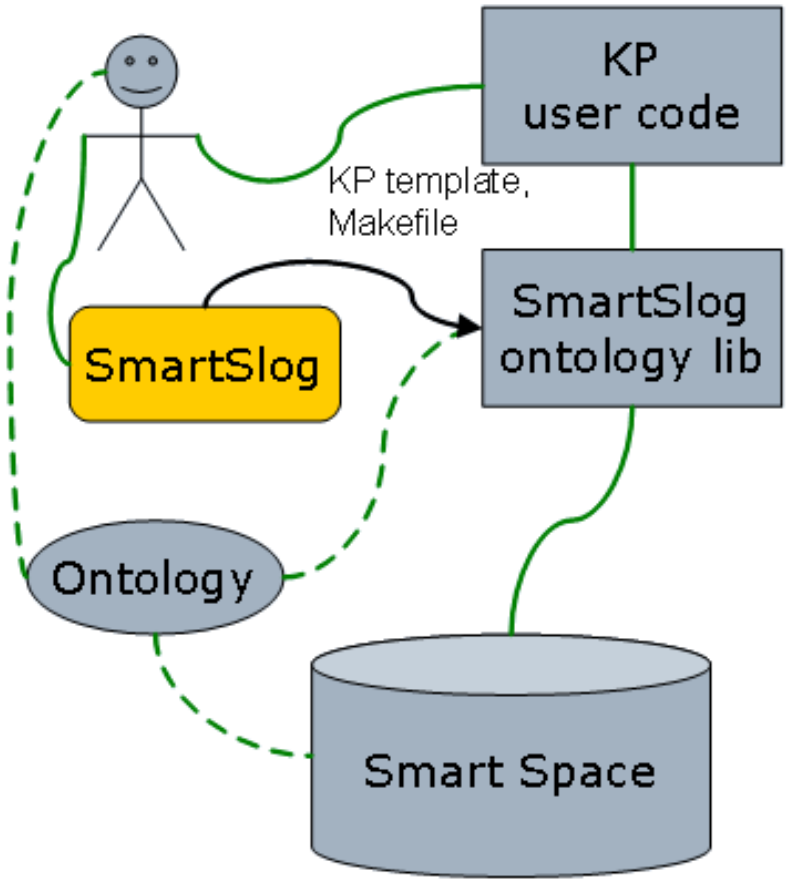
Low-level (RDF triple)	High-level (OWL object)
Whiteboard, Whiteboard-Qt *C/Glib, C/Dbus, C++/Qt (Smart-M3)*	Smart-M3 ontology to C-API generator *C/Glib, C/Dbus (Smart-M3)*
Smart-M3 Java KPI library *Java (University of Bologna and VTT)*	Smart-M3 ontology to Python generator *Python (Smart-M3)*
M3-Python KPI (m3_kp) *Python (Smart-M3 distribution)*	SmartSlog *ANSI C, C# (Petrozavodsk State University)*
C# KPI library *C# (University of Bologna)*	



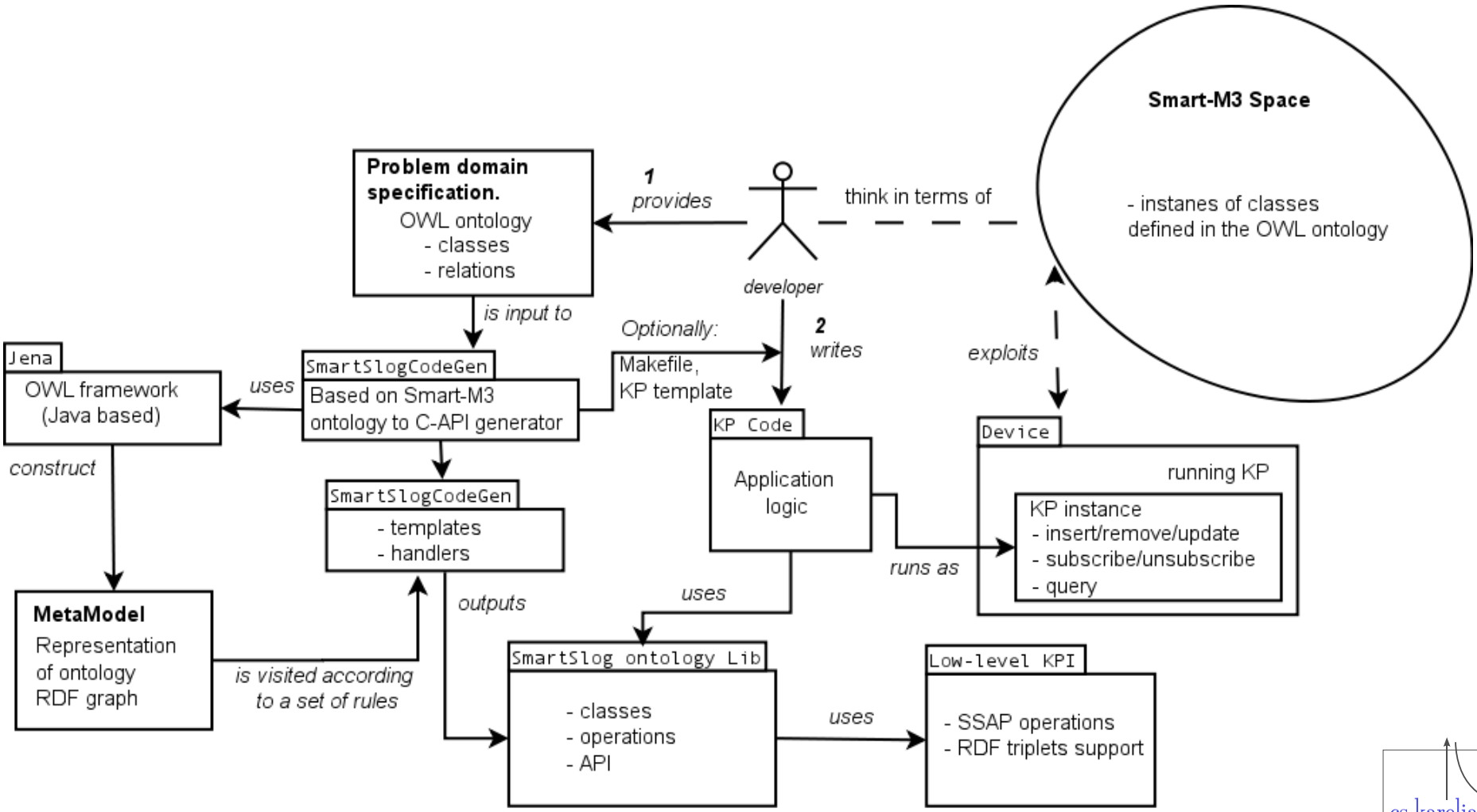
The Problem

- **Simplifying KP code using high-level OWL terms**
  - SIB uses low-level RDF triples
  - KP uses high-level abstractions
- **Speed development of huge amount of KPs**
  - Multilingual support
  - Cross-platform code generation
- **Target devices could be low-performance**
  - Subset of ANSI C version
  - Modest code schemes

These criteria are controversial, efficient tradeoff is a challenging problem



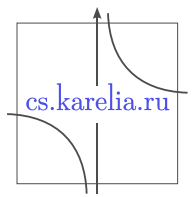
High-level scheme



Code Generation

Refers to a class of source code generators
Transformation approach of automatic programming

- Java-based CodeGen
- Static templates/handlers scheme
- **Templates** are “pre-code” of data structures
  - implementation of ontology classes
  - implementation of properties for classes
  - tags $\langle \text{name} \rangle$ instead of proper ontology names
  - dependence on the mediator library (KP$\leftrightarrow$SIB) (SmartSLog uses KPI_low library)
- **Handlers** transform templates into final code
  - Replacing tags with the names taken from the ontology
  - Executed when the ontology graph is analyzed (CodeGen calls Jena framework)



OWL mapping to code

Multilingual library generator for Smart Space ontology

- ANSI C ontology library (low-performance devices)
- C# ontology library (.NET framework, Windows OS)

	ANSI C code	C# code
ontological class structure	`typedef struct class_s {...} class_t;`	`class OntClass {...}`
ontological property of class structure	`typedef struct property_s {...} property_t;`	`class Property {...}`
ontological individual structure	`typedef struct individual_s {...} individual_t;`	`class Individual {...}`

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Easy to develop: mobile phone KP code

1. Individual creation, property setting and sending it to SS:

```
individual_t *mobile = new_individual(CLASS_MOBILEPHONE);
set_property(mobile, PROPERTY_NAME, "mob");
set_property(mobile, PROPERTY_ISCALLING, "false");
.  .  .
ss_insert_individual(mobile);
```

2. Waiting for income call and property updating:

```
while(1) {
 wait_call();
 ss_update_property(mobile, PROPERTY_ISCALLING, "true");
 wait_call_ending();
 ss_update_property(mobile, PROPERTY_ISCALLING, "false");
};
```

Easy to develop: music player KP code

1. Individual creation, property setting and sending it to SS:

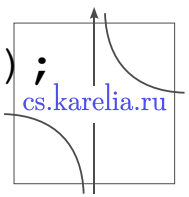
```
individual_t *mobile = new_individual(CLASS_MOBILEPHONE);
individual_t *player = new_individual(CLASS_PLAYER);
. . .
```

2. Subscribe to property:

```
subscription_container_t *container =
new_subscription_container();
add_data_to_list(prop_list, PROPERTY_ISCALLING);
add_individual_to_subscribe(container, player, prop_list);
ss_subscribe_container(container, true);
```

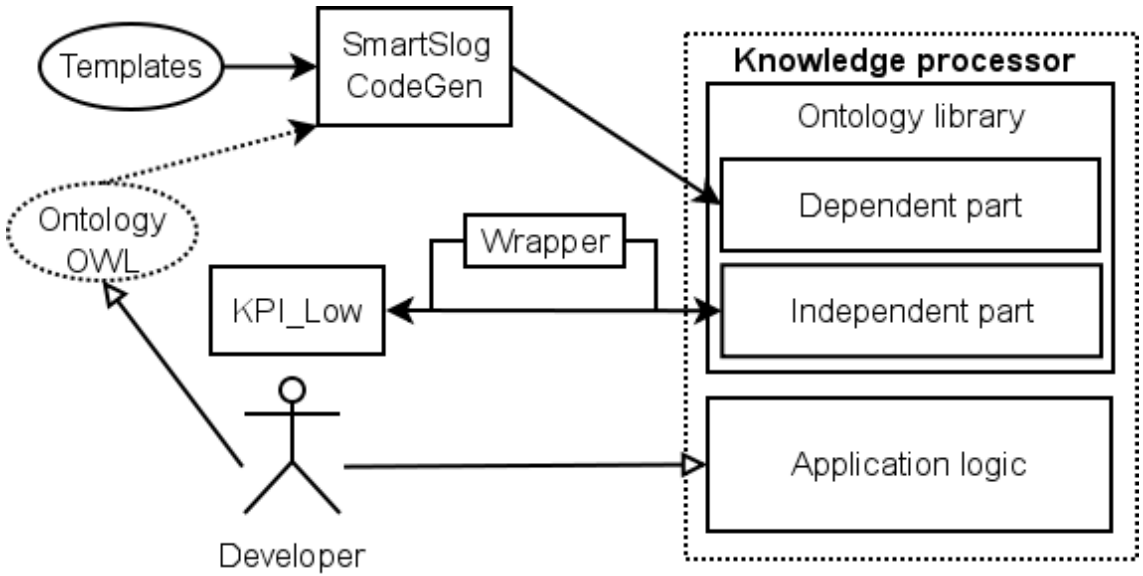
3. Check if phone calling and turn on/off volume:

```
while(1) {
 is_calling = get_property(mobile, PROPERTY_ISCALLING);
 if (is_calling == "true") set_sound_on(false);
 else set_sound_on(true);
 wait_subscribe(container_counter);
```



Implemented optimizations

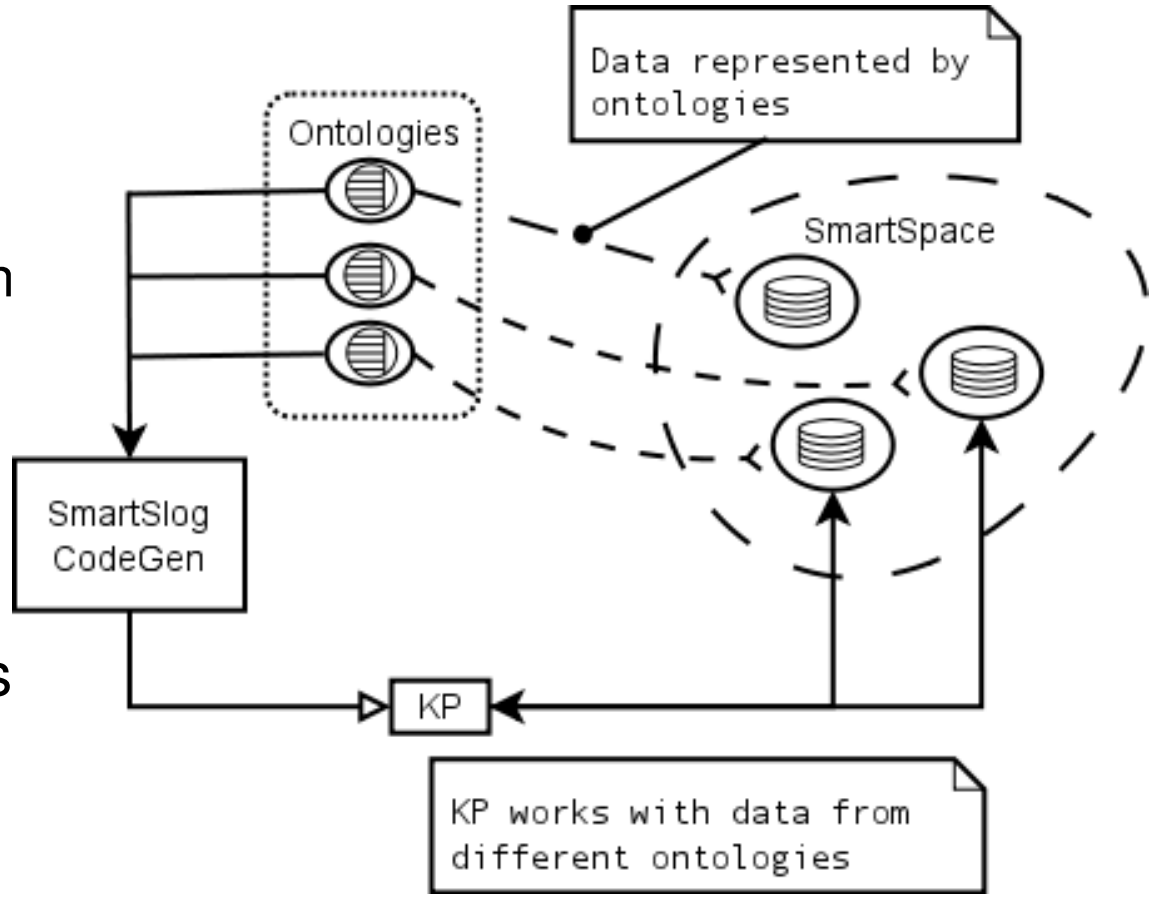
1. Generating ontology dependent part
2. Available ontology independent part (.a or .so library)
3. Memory control
4. Local data structures
5. Threading



Ontology composition

- Ontology integration:
  - Complete integration
  - Partial integration

Developer can manipulate with several knowledge sets in the smart space via a single KP.



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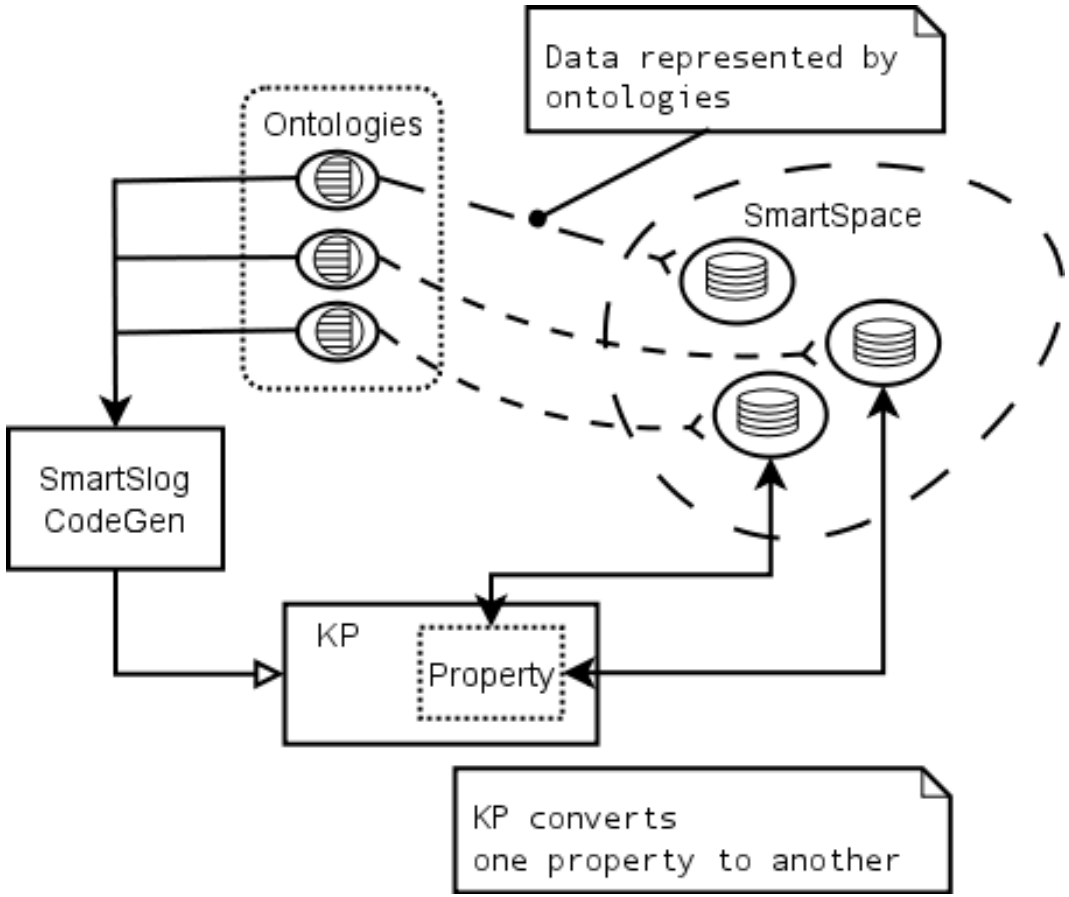
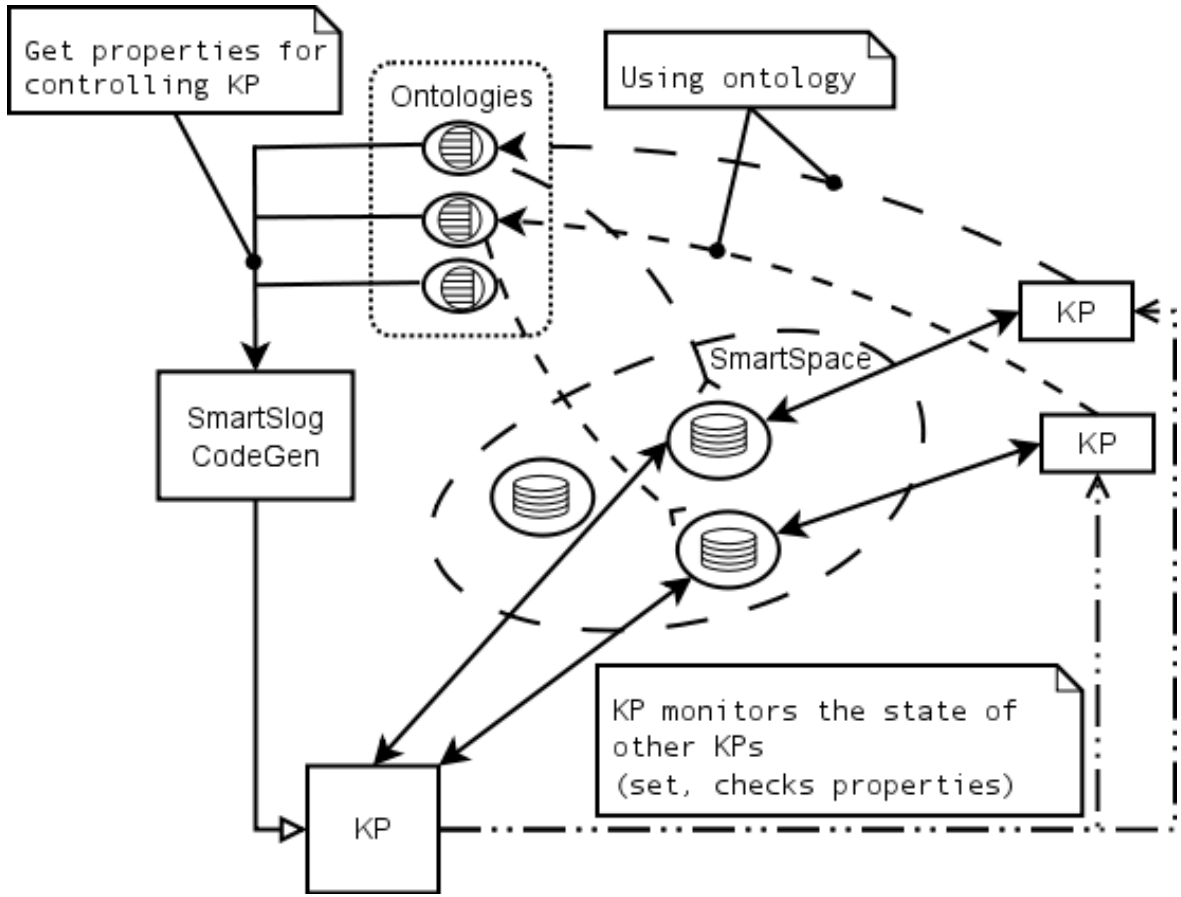
Ontology composition

- Bridge properties:
  - Many properties represented by one
  - Access the same data through active property
  - Background transformation of data



Ontology composition

- KP controller:
  - Controls ontology entities that are shared other KPs
  - Controls state of other KP
  - Decides further control actions



Case studies:

- Smart conference
- Smirnov et al. 2009 (KP is used for resolving the problem of simultaneous access to the smart space content)

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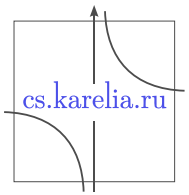
Knowledge patterns

- A data model that allows defining ontological objects
  - filtering locally available objects
  - searching new objects in the smart space
- Evaluation
  - correctness of defining objects
  - efficiency of processing

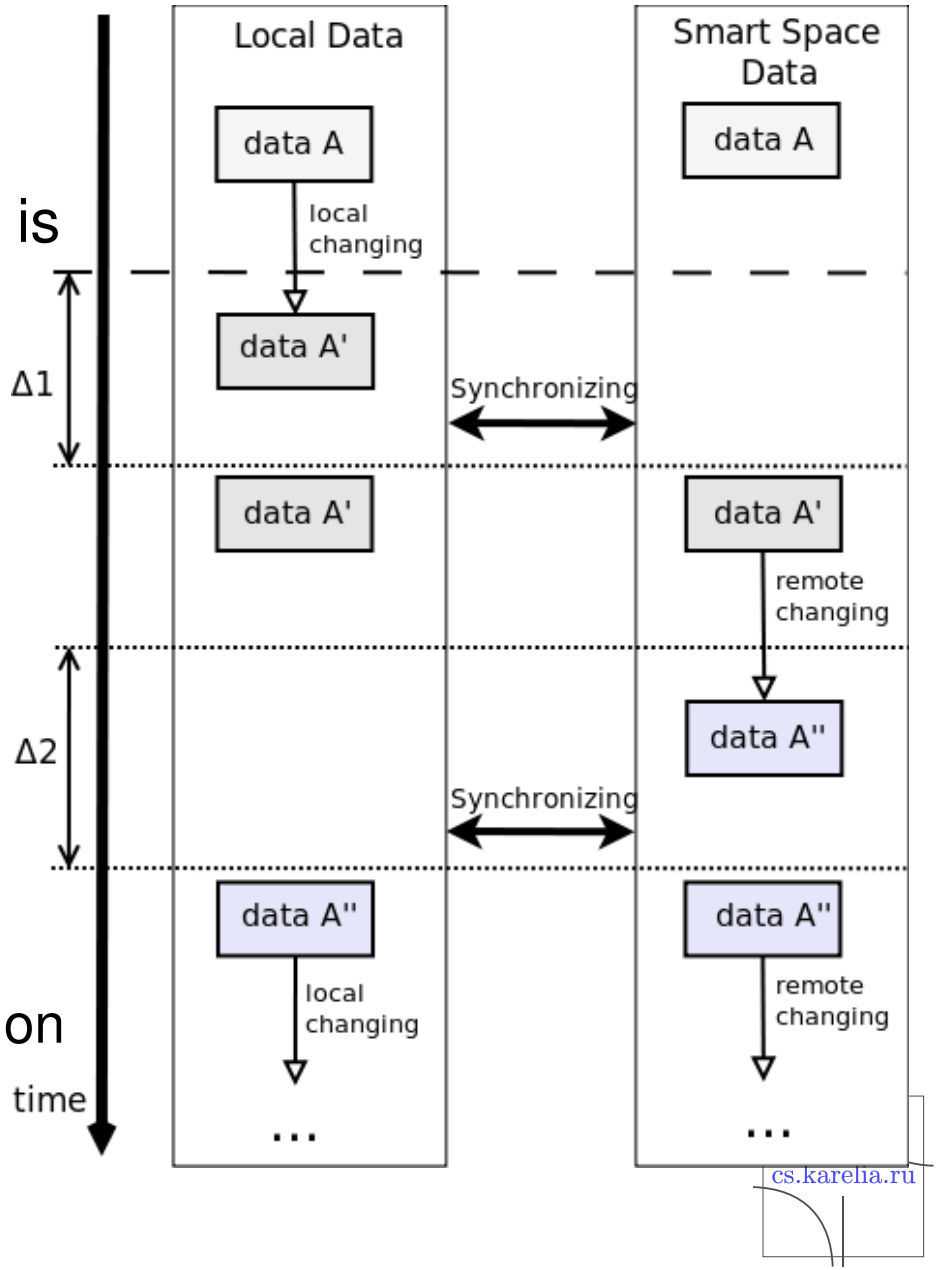
Filtering is used for transferring/delivering necessary parts of objects to/from the smart space.

Searching is used to deliver (search) new objects, existing in SS.



Synchronization

- SmartSlog data synchronization is subscription
  - blocking (synchronous subscriptions)
  - none-blocking (asynchronous subscriptions)
- Two ways to define objects to synchronize
  - explicit pointing
  - auto-marking for synchronization
- Mechanism for determination of synchronization moments

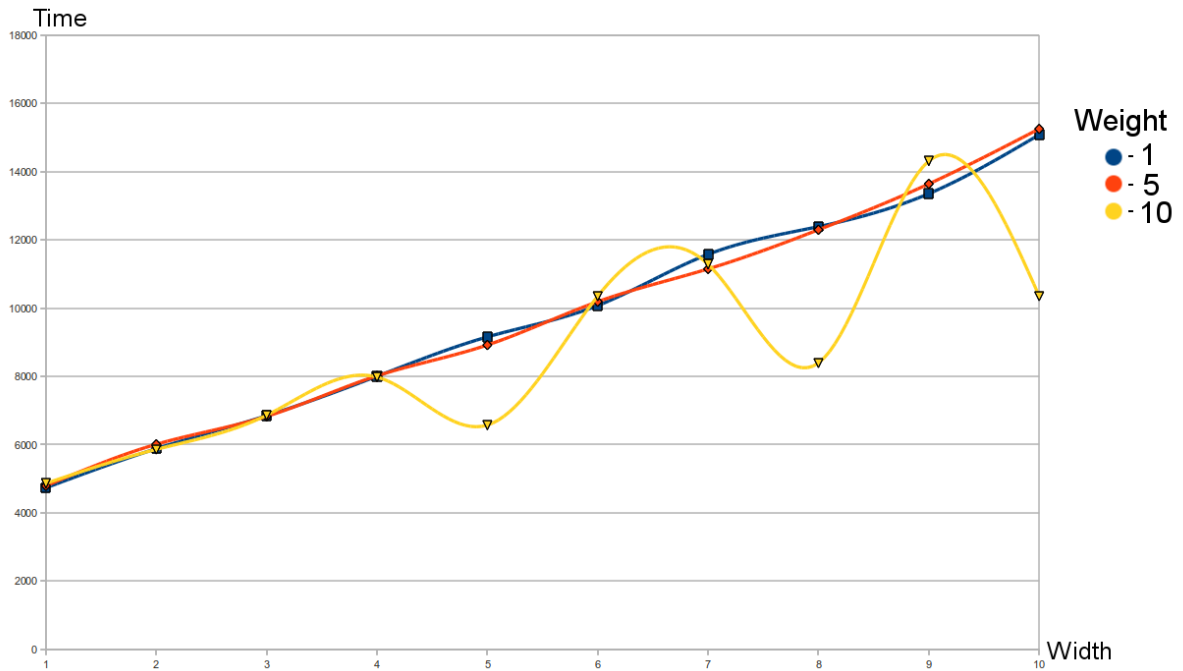


Performance evaluation

Starting performance evaluation

- OWL mapping performance
- Synchronization performance

Example of results:



Conclusion

- SmartSlog is a tool that supports efficient programming such devices for participating in smart space applications
  - Cross-platform and Multilingual
  - Code is compact due to high-level ontology style
- Future directions
  - Ontology manipulations
  - Optimizations
- Developers wiki:
  `http://oss.fruct.org/wiki/SmartSlog/`
- Open source code:
  `http://sourceforge.net/projects/smartslog/`

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Thank you!