Fault Tolerance Support of Smart-M3 Application on the Software Infrastructure Level

Ivan Galov, Dmitry Korzun

Petrozavodsk State University
Department of Computer Science

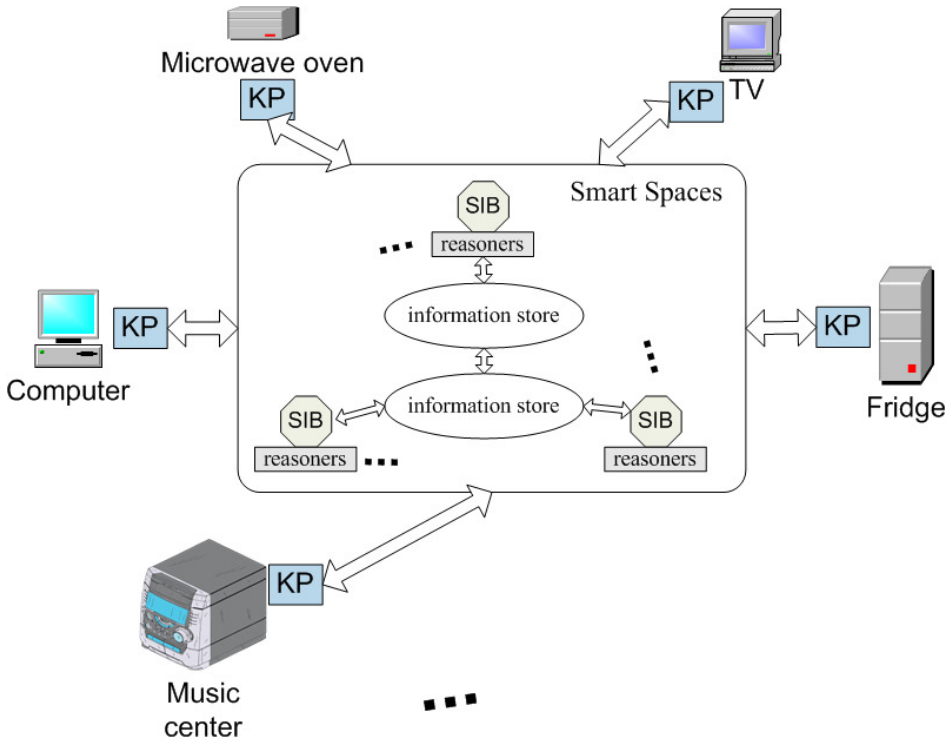
Supported by project # 1481 from the basic part of state research assignment # 2014/154 of the Ministry of Education and Science of the Russian Federation, project # 14-07-00252 of the Russian Fund for Basic Research, project 14.574.21.0060 (RFMEFI57414X0060) of Federal Target Program “Research and development on priority directions of scientific-technological complex of Russia for 2014–2020”.

16th FRUCT Conference

October 30, 2014, Oulu, Finland

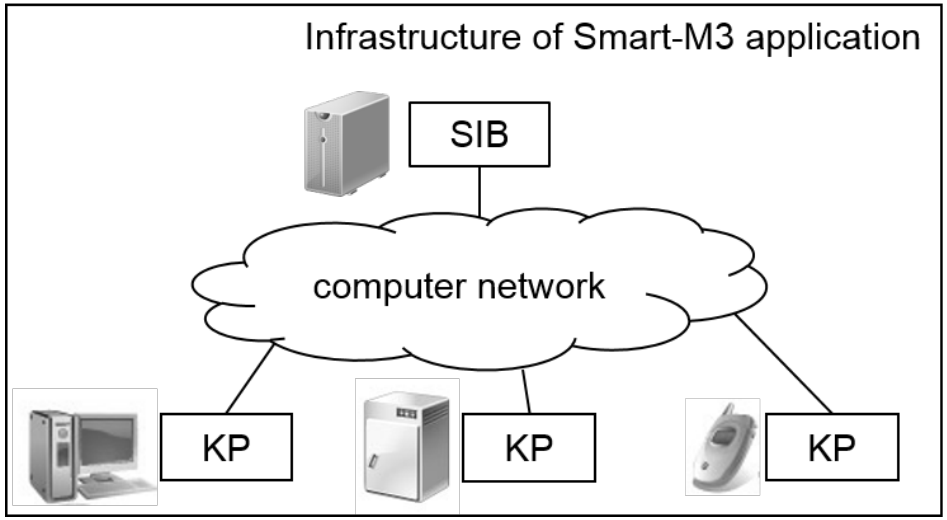
Smart-M3 platform

- Semantic information brokers (SIBs) maintain smart space content in low-level RDF triples
- Application consists of several knowledge processors (KPs) running on various devices
- An agent sharing ad-hoc knowledge across numerous domains
  - join, leave
  - insert, update, remove
  - (un)subscribe
- Interaction between KPs is implemented using publish/subscribe mechanism



Software Infrastructure of Smart-M3 Applications

Software infrastructure: the means for application operation



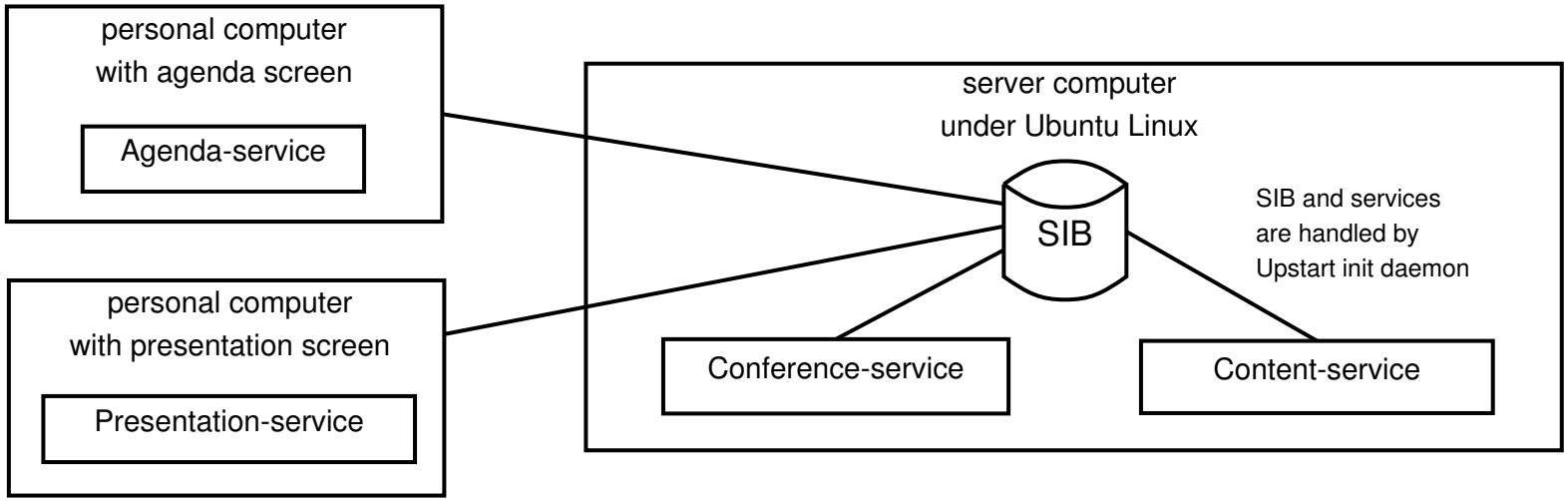
Infrastructural KPs are responsible for service construction and delivery

Infrastructural KP deployment options:

1. Clustering near the SIB
2. Device-aware location
3. Server-oriented location (non-SIB)

Example: SmartRoom system

- Holding conferences, meetings, and lectures
- Personalized interaction with room participant
- Participating using mobile devices



- SIB is deployed either locally or on a remote machine
- Conference-service: conference runtime management
- Presentation-service: slide show of current speaker
- Agenda-service: visual activity agenda
- Content-service: storage of participants' materials

Application Dependability

Dependable application: “reliance can justifiably be placed on the service it delivers” (M.R. Lui et al., 1996)

- Availability: readiness for usage.
- Reliability: continuity of service.
- Safety: nonoccurrence of catastrophic consequences on the environment.
- Confidentiality: nonuccurrence of unauthorized access.
- Integrity: nonoccurrence of improper alterations of information.
- Maintainability: ability to undergo repairs and evolutions.

Fault tolerance: application is capable to deliver its services in the presence of faults

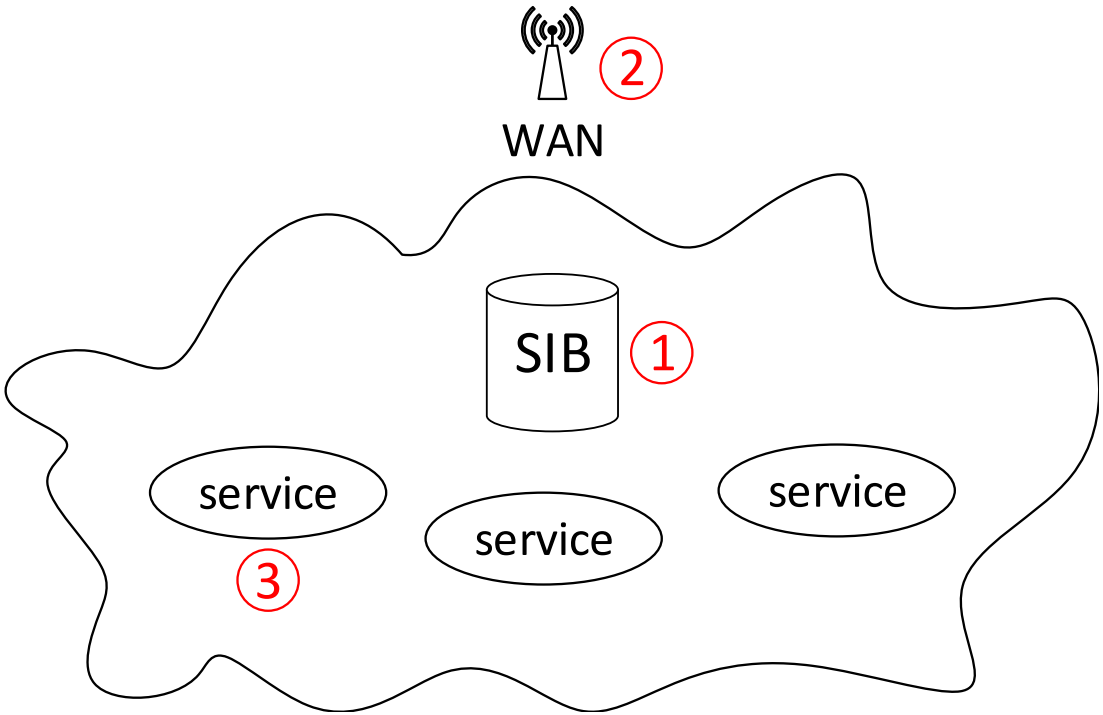
Smart-M3 Application Dependability

Lacks of reliability and integrity

Subscription is the most failure-sensitive operation

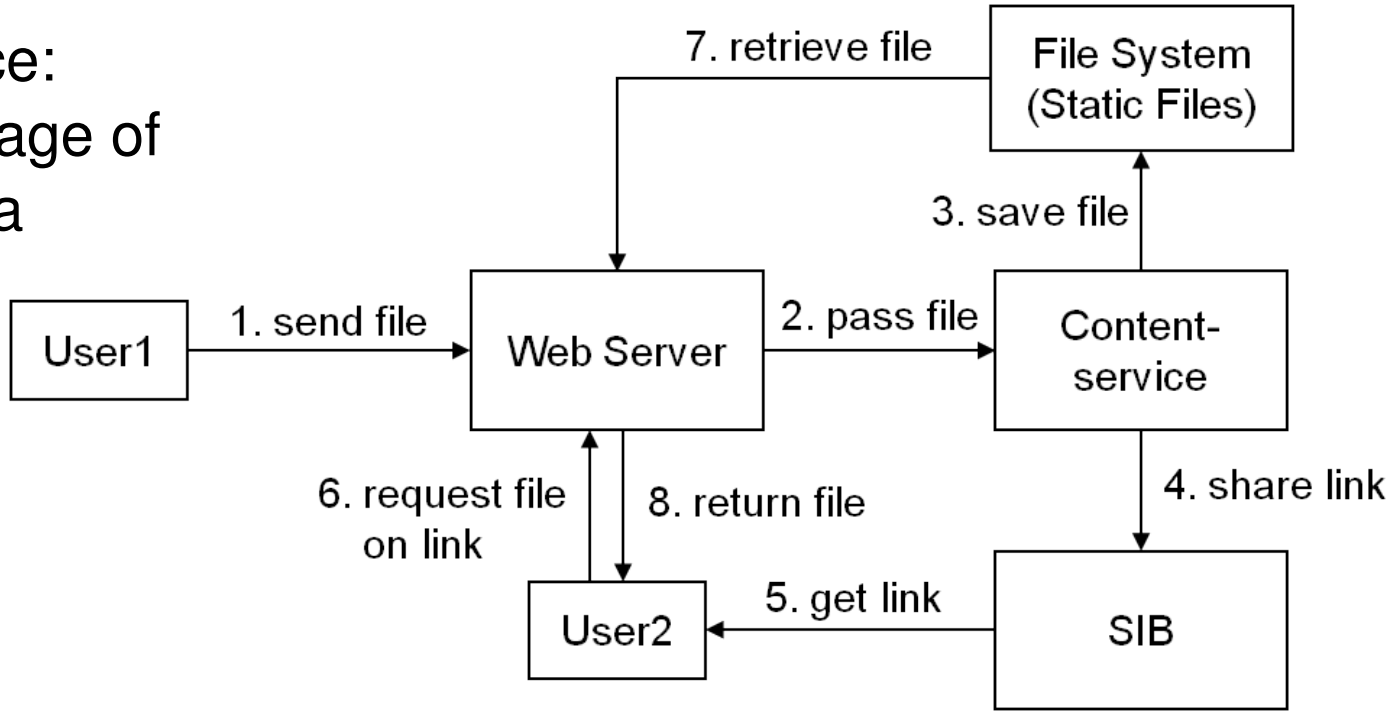
Failure reasons:

1. SIB: software error (freezing, crashing); lost subscription connection with KPs; data loss (overload)
2. Wireless network: subscription connection breaks; data packets loss
3. Infrastructural KP: lost network connection with the SIB; software error (crashing)



Solutions

1. Content-service: persistent storage of volumetric data
   - presentations
   - images
   - audio
   - video



2. Mechanisms for fault tolerance of subscription
   - Subscription control mechanism: active regular checks for subscribed data
   - Restart/reconnection: KP reestablishes network connection with the smart space

Subscription Control

- Failure situations:
  - subscription indication was lost
  - subscription connection was disrupted
- Proactive check (subscription) is augmented with active checking
- If subscribed data are changed — failure has occurred
- Challenges:
  - how to detect information changes
  - no clear criterion on identifying breaks in subscription
  - check intervals
- Usage notification model: subscribe on data about changes, not on changing data
  I. Galov and D. Korzun, “Notification model for Smart-M3 applications”, NEW2AN/ruSMART 2014, LNCS 8638
- Not implemented yet: also crucial for mobile clients (A. Vdovenko)

Restart/Reconnection

- Restart: application is shut down and launched again
- Reconnection: application is still running but connection to SIB is re-established

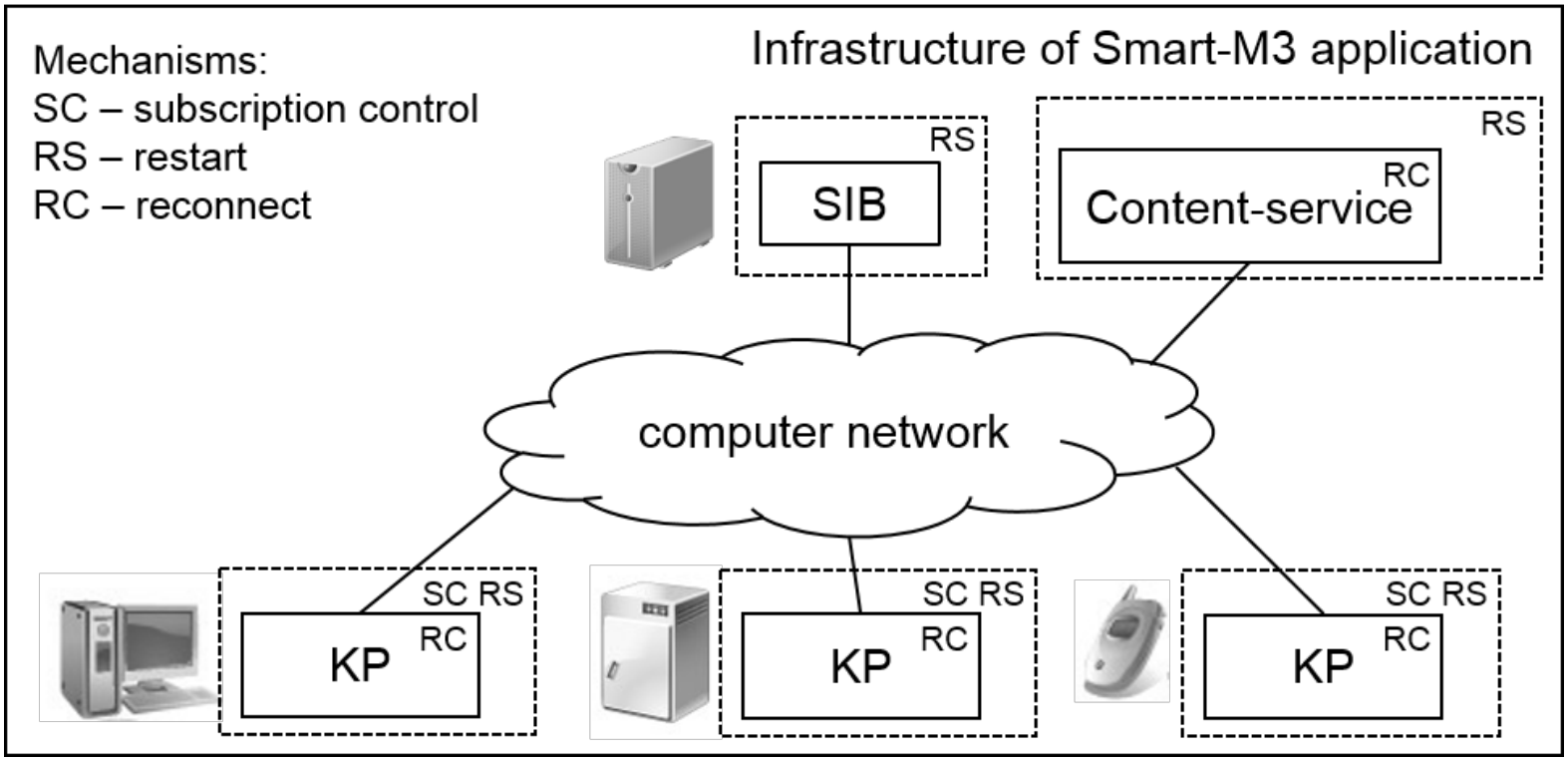
Usage in SmartRoom:

Infrastructure element	**Restart**	**Reconnection**
SIB	+ (auto)	−
Conference-service	+ (auto)	−
Agenda-service	+ (manual)	+ (manual)
Presentation-service	+ (manual)	+ (manual)
Content-service	+ (manual)	−

Restart implementation: launching on the server computer with help of Ubuntu Upstart init daemon (configuration files):

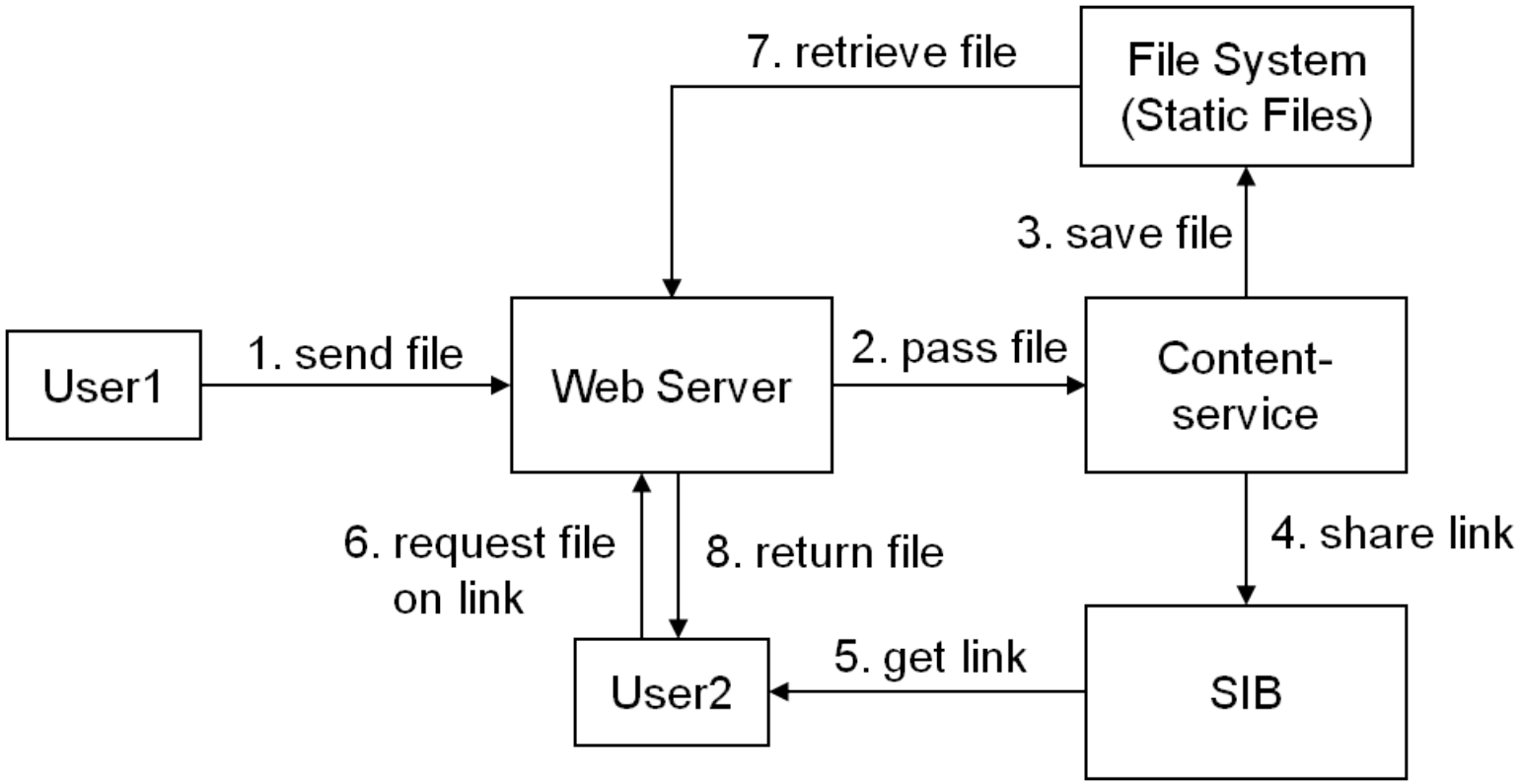
$$\text{redsibd} \rightarrow \text{sib-tcp} \rightarrow \text{conference-service}$$

Mechanisms Deployment



Performance Evaluation: Content-service

Server computer: Ubuntu Linux, Intel Xeon 2.30GHz, 4GB RAM



Content-service file (10M) upload time on the web server:

- Apache: 1.814 sec. (standard deviation is 0.014)
- nginx: 1.842 sec. (standard deviation is 0.030)

Performance Evaluation: Restart/Reconnection

- Server computer: Ubuntu Linux, Intel Xeon 2.30GHz, 4GB RAM (SIB, Conference-service, Content-service)
- Personal computer: Windows, Intel Core 2 Quad 2.40GHz, 8GB RAM (Presentation-service, Agenda-service)
- Time between service terminating and starting (until readiness) was measured

Infrastructure element	**Restart (sec)**	**Reconnection (sec)**
SIB	1.045	–
Conference-service	2.023	–
Agenda-service	1.350	0.134
Presentation-service	0.230	0.075
Content-service	2.193	–

Conclusion

- Software infrastructure for the case of Smart-M3 applications
- Solutions for Smart-M3 applications fault tolerance:
  - Content-service to control volumetric factual data
  - Mechanisms for subscription control (fault detection) and recovery (when fault has happened)
- Experimental evaluation for SmartRoom system

Thank you for attention

E-mail: galov@cs.karelia.ru