

Runtime Feature Interaction Detection and Resolution in Integrated Services of Networked Home Appliances

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Home Network System (HNS) ^{[1][2][3][4]}

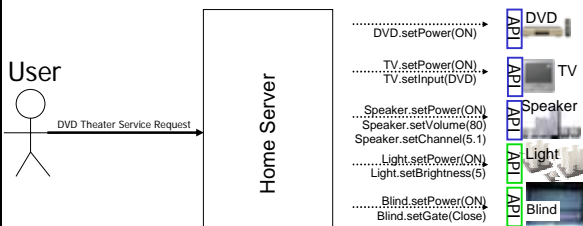
- HNS is a system consisting of several networked home appliances and add more value to the daily life.
- The appliances in HNS are controlled together to provide integrated services.
 - DVD, TV, Lights, Air Conditioner, Thermometer, etc.

[1]EUNA, (2004) Digital Living Network Alliance. [Online]. Available: <http://www.dlna.org/> [2004].
[2]SCHNITZ, (2004) SCHNET CONCEPTS. [Online]. Available: <http://www.schnitz.de/gb/eng/ov/index.htm> [2004].
[3]Hitachi, (2004) Horaso Network Service. [Online]. Available: <http://rs.horaso.com/> [2004].
[4]LG E+, (2004) Home Network. [Online]. Available: <http://www.lge.com/products/home/network/home-network.asp>

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HNS integrated services with Server Centralized Architecture[†]

- Home Server controls each appliance APIs for HNS integrated services.



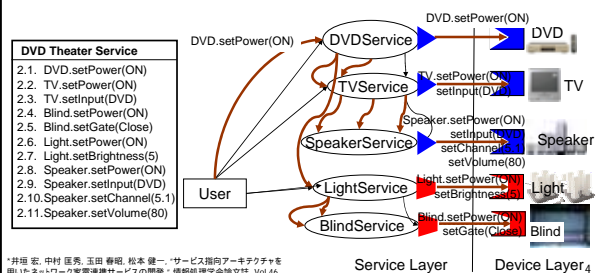
The HNS consists of a set of appliance APIs invoked by home server.

† Hitachi Home & Life Solutions Inc., [ONLINE] "horaso network." <http://www.horaso.com/>
Matsushita Electric Industrial Co., Ltd., "Kurashi-net" [ONLINE] <http://national.lg/appliance/product/kurashi-net/>

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HNS integrated services with Service Oriented Architecture*

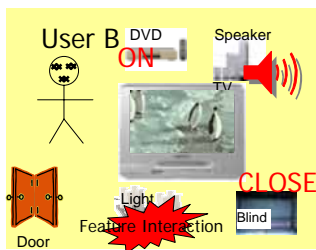
- Each appliance communicates with each other without centralized server, autonomously for executing the HNS integrated services.



*井垣 宏, 中村 匡秀, 玉田 春昭, 松本 健一, "サービス指向アーキテクチャを用いたネットワーク家電連携サービスの開発," 情報処理学会論文誌, Vol.46, No.2, pp.314-326, Feb. 2005.

Feature Interactions on Home Network System

Feature Interaction between DVD Theater Service and Coming Home Service



DVD Theater Service

- When a user switches on the DVD player, the TV and the Speaker are turned on in DVD mode, the blind is closed, the brightness of the lights is minimized

Coming Home (Light) Service

- When a user comes home, the light gets bright.

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Previous Research: FI on HNS

- We formalized FI problems and proposed the framework for FI detection*.
 - Formalization: Appliance Interactions and Environment Interactions
 - Framework: Appliance Modeling as an object consisting of properties and methods.

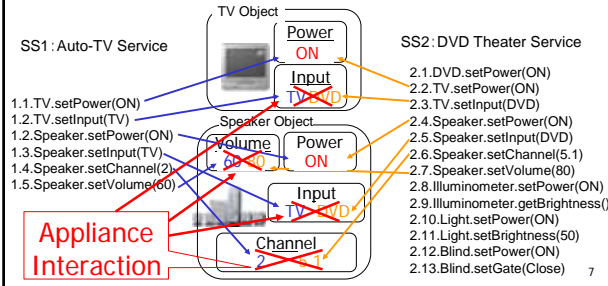
*井垣 宏, 中村 匡秀, 松本 健一, "家電機器連携サービスにおけるサービス競合検出システム," 信望扶輪, DC2004-23, pp.11-16, 2004.

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Appliance Interaction

Method m, n in different service satisfy at least one of the following conditions about appliance property

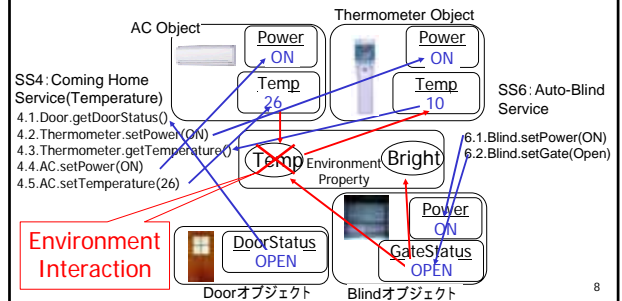
- There exists an appliance property which doesn't satisfy the post conditions of m and n simultaneously.
- There exists an appliance property which doesn't satisfy the pre conditions of m and the post conditions of n, simultaneously.



Environment Interaction

Method m, n in different service satisfy at least one of the following conditions about appliance property

- a race condition between two 'writes' on the common environment properties.
- non-interchangeable 'read' and 'write' on the common environment properties.



Offline FI detection and its limitation

| | SS1 | SS2 | SS3 | SS4 | SS5 | SS6 | SS7 |
|-----|--|-----|-----------|-----|------------|-----------|---|
| SS1 | (1,2,2,3) (1,4,2,9) (1,5,2,10) (1,6,2,11) | | | | (1,6,5,3) | | (1,1,7,2) (1,2,7,2) (1,3,7,4) (1,4,7,4) (1,5,7,4) (1,6,7,3) (1,6,7,4) |
| SS2 | | | (2,7,3,5) | | (2,11,5,3) | (2,5,6,2) | (2,1,7,1) (2,2,7,2) (2,3,7,2) (2,4,7,9) (2,5,7,8) (2,5,7,9) (2,6,7,7) (2,7,7,6) (2,7,7,7) (2,8,7,4) (2,9,7,4) (2,10,7,4) (2,11,7,3) (2,11,7,4) |
| SS3 | | | | | | | (3,2,7,5) (3,3,7,5) (3,4,7,7) (3,5,7,6) (3,5,7,7) |
| SS4 | | | | | | | (4,2,7,9) (4,3,7,9) (4,4,7,8) (4,5,7,8) |
| SS5 | | | | | | | (5,3,7,9) (5,3,7,4) |
| SS6 | | | | | | | (6,1,7,11) (6,2,7,10) (6,2,7,11) |
| SS7 | | | | | | | |

- Offline FI detection: FI detection method based service scenarios
- Results of the detection enable us to rebuild the service scenarios so that any interaction is avoided
 - limits flexible creation and deployment of the service scenarios

Objective and approach

Objective

- Runtime FI detection and resolution

Approach

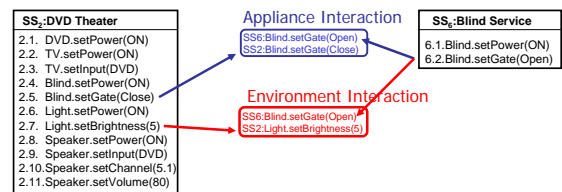
- STEP1: The runtime appliance method and service scenario containing its method are acquired.
- STEP2: FI detection are performed for a set of appliance methods in a newly executed scenario and in the information of STEP 1

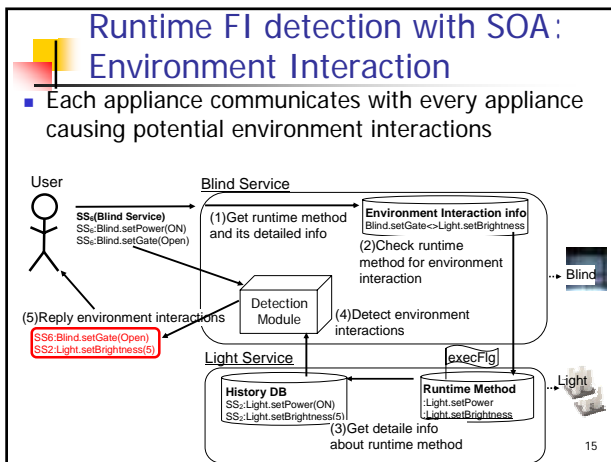
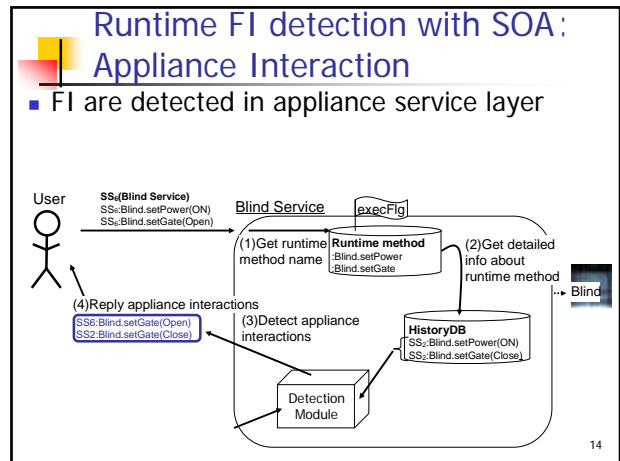
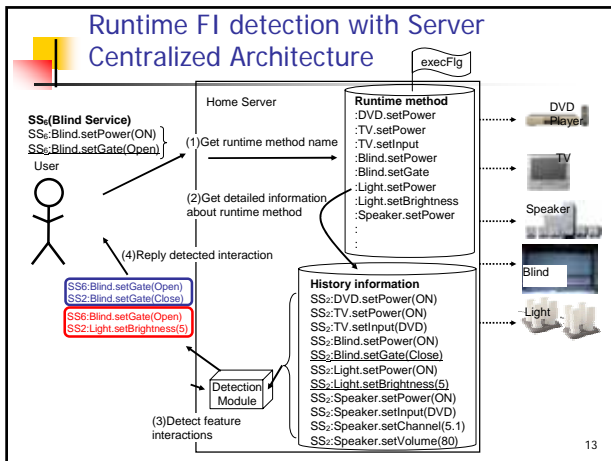
Key Idea

- execFlg
 - execFlg records the name of runtime Appliance method
- History information DB for appliance method
 - This DB has detailed information of the executed appliance method
 - E.g. SS2: DVD.setPower(ON)

Runtime FI detection

- If SS6(Blind Service) is executed while performing SS2(DVD Theater Service), the following FI are detected.





- ### FI resolution Schemes
- Rebuild Scenario
 - Based on the result of the offline detection. Rebuild the service scenarios (update, delete etc.).
 - Prompt User during runtime
 - Ask the users to determine manually how the interaction should be dealt with.
 - Prioritize Services
 - Assign static priorities to services.
 - Prioritize Methods
 - Assign static priorities methods.
 - Prioritize Users
 - Assign static priorities to users.
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Comparison of resolution approach

| | Resolution Approach | Required Function | Employment Cost | Merit | Demerit |
|---------------------|---------------------|---|---|--|--|
| Rebuild Scenario | Offline | Nothing | Scenario rebuilding | No required new functions | To resolve all interactions is harder |
| Prompt User | Online | Interaction result display, Runtime scenario updating | Runtime scenario updating in case of interactions occur | Most flexible interaction resolution | Required functions are complex. Service without user control aren't resolved |
| Prioritize Services | Online | Interface to prioritize, Runtime automated resolution | Prioritizing | Automated resolution | Difficult for users to prioritize |
| Prioritize Methods | Online | Prioritize interface, Runtime resolution | Prioritizing | Automated and flexible resolution per method | Difficult for users to prioritize |
| Prioritize Users | Online | Prioritize interface, Runtime resolution | Prioritizing | Automated resolution, Easy prioritizing | Lower priority user can't always execute services. |

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- ### Discussion
- FI resolution method has three view points: User, Service, Method.
 - Using multiple resolution schemes together achieves fine interaction management
 - Because each resolution approach has its merit and demerit
 - Hybrid Resolution Method are needed
 - In user level resolution, priority settings for parent and child are usable.
 - Services such as a security management which have the highest-priority, need service level management.
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Conclusion

- Runtime FI detection method for SCA, SOA based HNS
- FI resolution schemes are proposed.

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Future Research

- Hybrid FI resolution design
- Quantitative evaluation about FI detection

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■ Thank you

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