



University of Pittsburgh

Healthcare meets Internet of Things

CS2310: Multimedia Software Engineering

Daniel Petrov

School of Arts and Sciences

Department of Computer Science





Outline

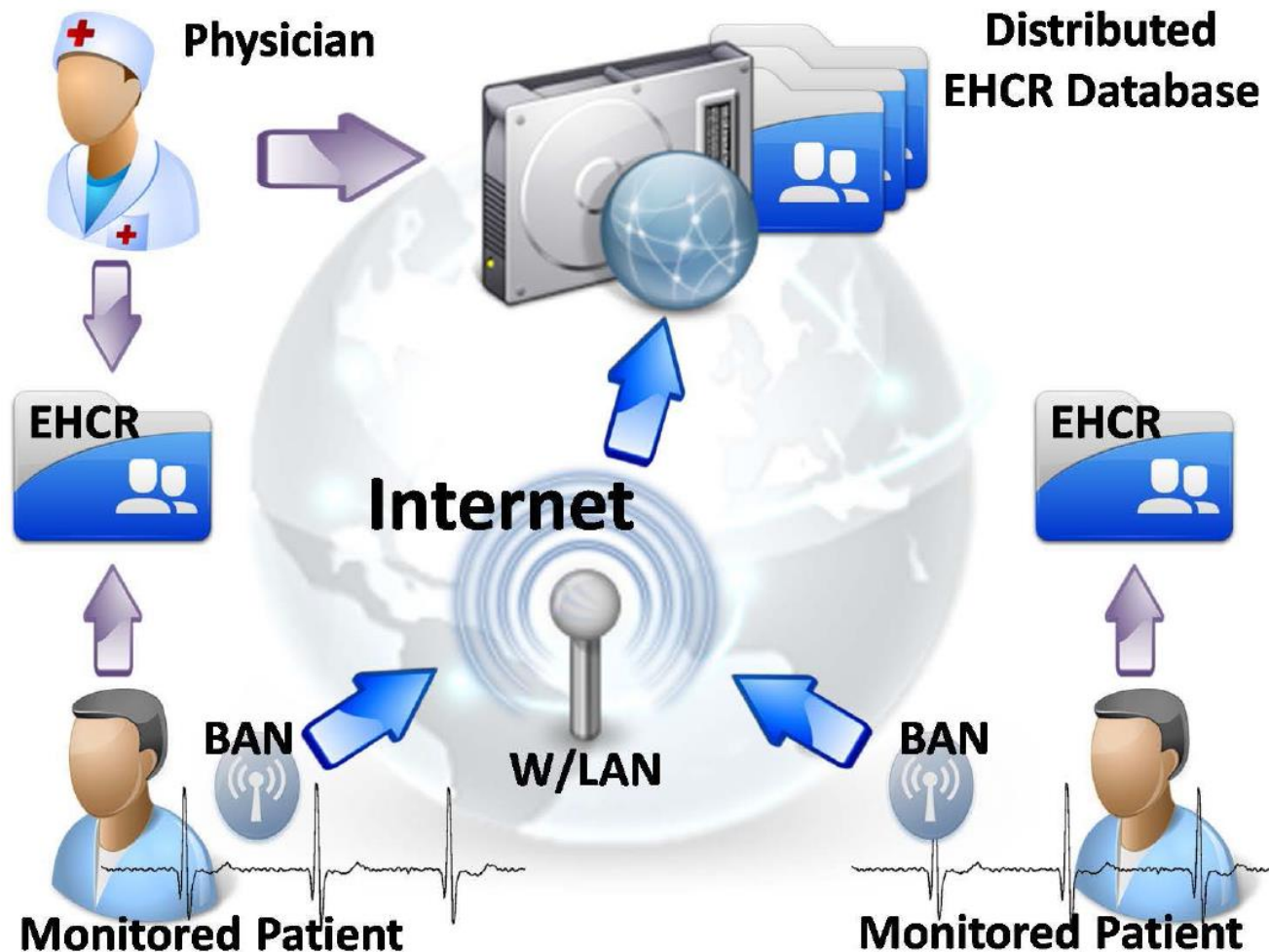
- Papers
- E-Health System Model
- WBAN and IoT
- E-Pharmacology



Papers

- Bui Z., Zorzi M., **“Health Care Applications: A solution Based on The Internet of Things”**, ISABEL 2011, Barcelona, Spain
- Jara A., Zamora M., Skarmeta A., **“Drug identification checker based on IoT to minimize adverse drug reactions and improve drug compliance”**, Pers Ubiquit Comput 2014

e-Health System Model





Requirements to the System

- Interoperability
- Bounded latency and reliability
- Privacy, authentication and integrity



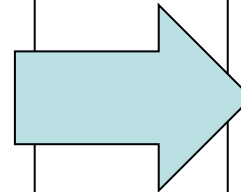
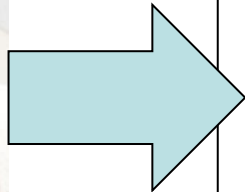
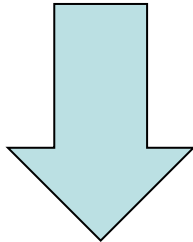
Device Classification

- Belonging to **constrained** network
 - Low energy availability;
 - 250 kb/s bandwidth
 - Several MHz computational power
- Belonging to **unconstrained** network
 - None of the limitations above
 - Cellular phones
 - Computers

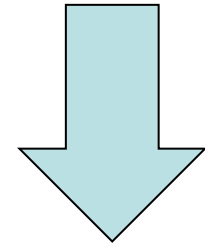
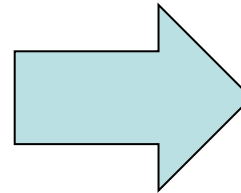
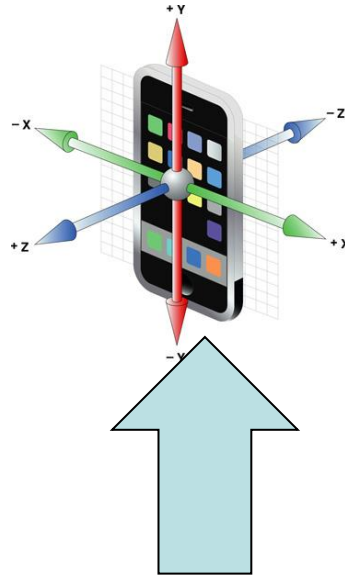
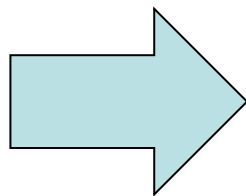
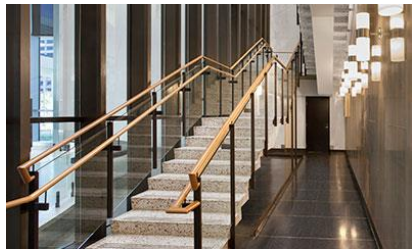
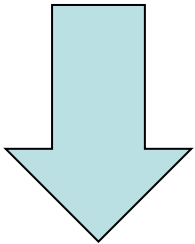
Scenario



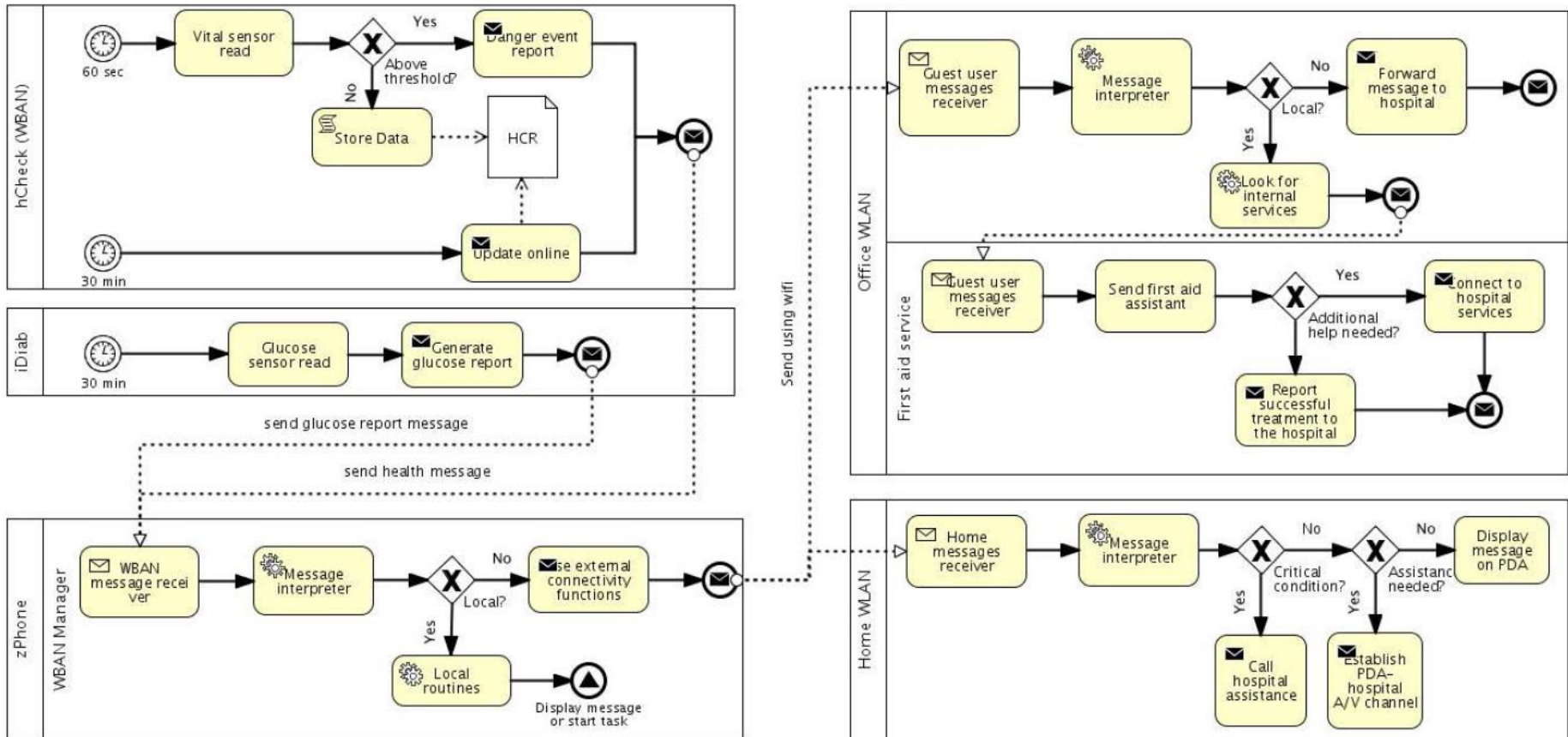
Bernard, 62, diabetes



Scenario (cont.)



Process Model (BPMN)



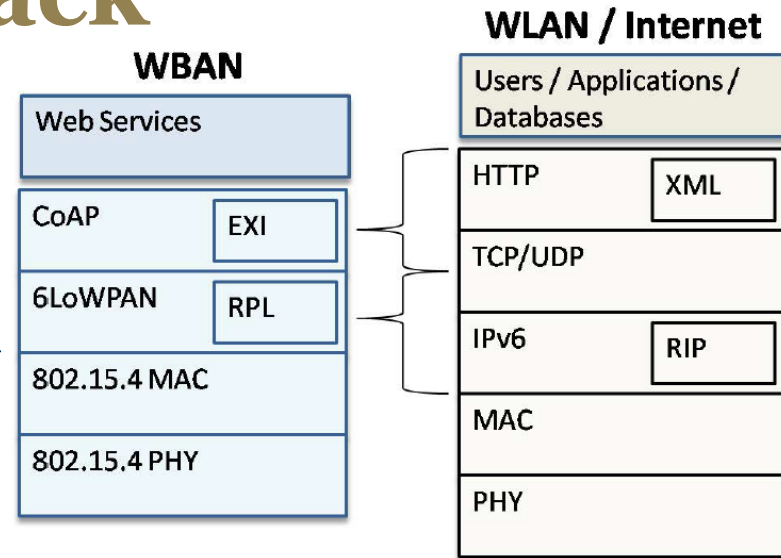


Communication

- Unconstrained networks devices
 - WLAN (802.11)
 - GPRS, WCDMA, LTE
- Constrained networks devices
 - WBAN

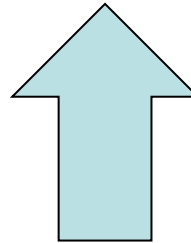
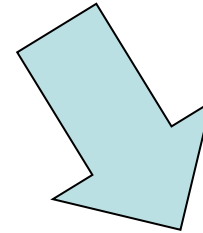
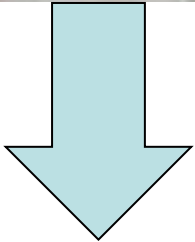
WBAN Protocol Stack

- IPv6 over Low power Wireless Personal Area Networks (IETF, ETSI)
 - IPv6/UDP header (40B) to HC1 header (1B)
- Routing Protocol for Low power and lossy networks - RPL (IETF, ROLL group)
- Constrained Application Protocol (CoAP)
 - Constained RESTful Environments (CoRE) working group;
 - HTTP GET, POST, DELETE, UPDATE methods
- Efficient XML Interchange (EXI) format (W3C consortium)
 - Mitigate size and parsing complexity



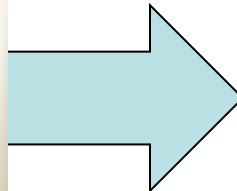


Scenario



DD FORM 1289 1 NOV 71 DOD PRESCRIPTION	
FOR: (Full name, address, & phone number; SS number if given) <u>John J. Doe, MMS, USA</u>	
<u>U.S.S. Never forgotten (DD 178)</u>	
MEDICAL FACILITY <u>U.S.S. Never forgotten (DD 178)</u>	DATE <u>23 Jan 85</u>
B (Superscription) gm or ml	
(Prescription)	<u>In Belladonna</u> 15 ml
	<u>Amphogel good</u> 120 ml
(Subscription)	<u>M + FT Solution</u>
(Signa)	<u>Sig. 5ml i/d o.c.</u>
REC'D <u>Worm</u> EXT NO <u>123456</u>	EXP DATE <u>22/85</u> FILLED BY <u>CAF</u>
B. NUMBER <u>10072</u>	SIGNATURE <u>Wagon D. Doe</u> <u>22DR, MC USA</u>

EDITION OF 1 JAN 80 MAY BE USED FOR
U.S. (RUSSEL 612-8251)

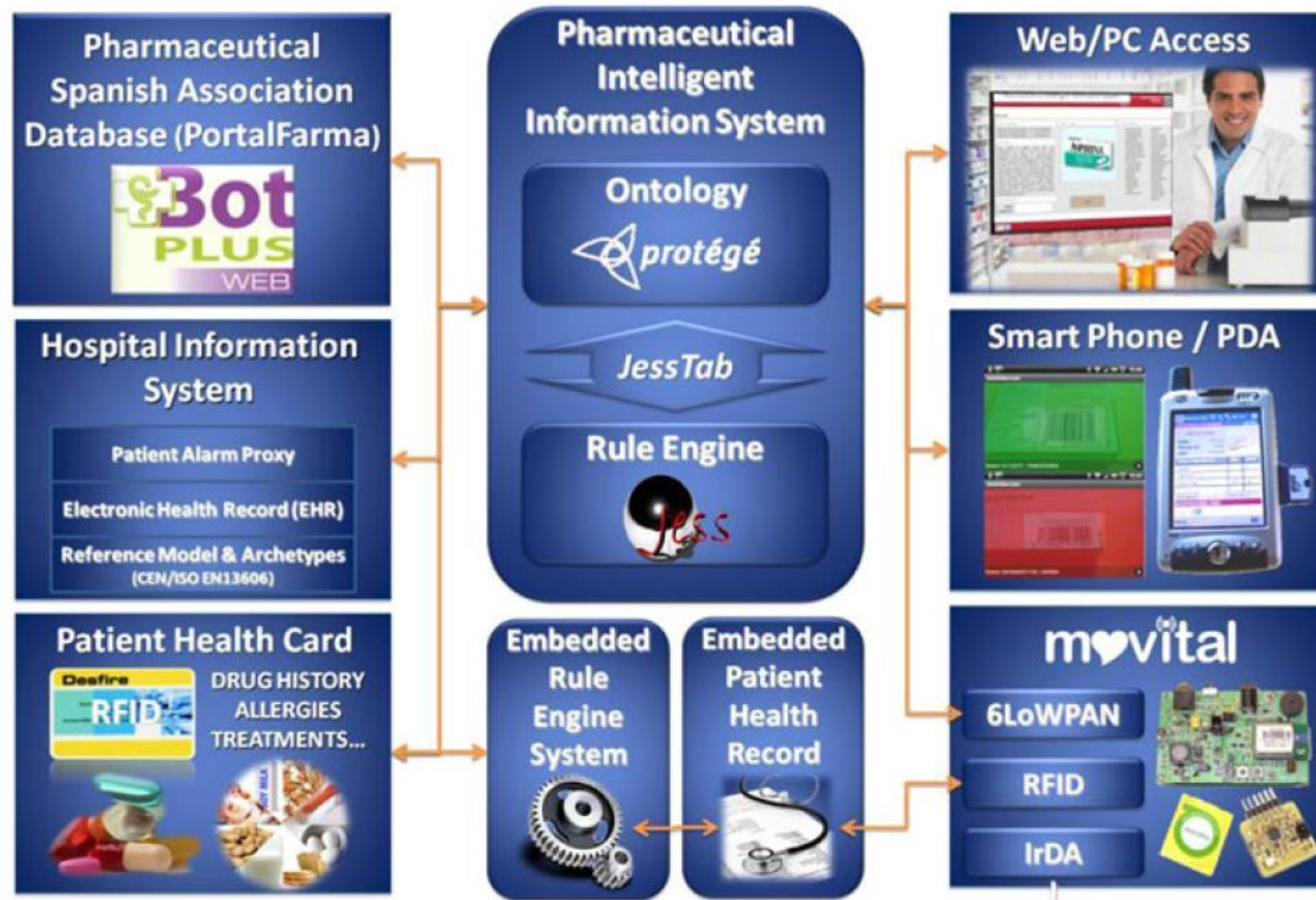


Daniel Petrov

Statistics

- Adverse Drug Reaction (ADR)
 - 6.7% through hospitals worldwide (8% in Spain, 6.5% in the United Kingdom)
 - 0.32% death rate
- Ambient Assisted Living (AAL) environments
 - 15% of the patients observe non-compliance to drug dosage and schedule

Solution Architecture



Solution Architecture (cont.)

Pharmaceutical Spanish Association Database (PortalFarma)



Drug	Indication	Indication Indicated	Indication Indicated	Indication Indicated
Captopril	Angiotensin, Captopril, Heart Failure, Hypertension, Myocardial Infarction	Indication Indicated	Indication Indicated	Indication Indicated
Clozapine	Angiotensin, Clozapine, Heart Failure, Hypertension, Myocardial Infarction	Indication Indicated	Indication Indicated	Indication Indicated
Diazepam	Angiotensin, Diazepam, Heart Failure, Hypertension, Myocardial Infarction	Indication Indicated	Indication Indicated	Indication Indicated
Diltiazem	Angiotensin, Diltiazem, Heart Failure, Hypertension, Myocardial Infarction	Indication Indicated	Indication Indicated	Indication Indicated
Doxycycline	Angiotensin, Doxycycline, Heart Failure, Hypertension, Myocardial Infarction	Indication Indicated	Indication Indicated	Indication Indicated
Etiology	Angiotensin, Etiology, Heart Failure, Hypertension, Myocardial Infarction	Indication Indicated	Indication Indicated	Indication Indicated
Furosemide	Angiotensin, Furosemide, Heart Failure, Hypertension, Myocardial Infarction	Indication Indicated	Indication Indicated	Indication Indicated
Hydrochlorothiazide	Angiotensin, Hydrochlorothiazide, Heart Failure, Hypertension, Myocardial Infarction	Indication Indicated	Indication Indicated	Indication Indicated
Insulin	Angiotensin, Insulin, Heart Failure, Hypertension, Myocardial Infarction	Indication Indicated	Indication Indicated	Indication Indicated
Lisinopril	Angiotensin, Lisinopril, Heart Failure, Hypertension, Myocardial Infarction	Indication Indicated	Indication Indicated	Indication Indicated
Metoprolol	Angiotensin, Metoprolol, Heart Failure, Hypertension, Myocardial Infarction	Indication Indicated	Indication Indicated	Indication Indicated
Nifedipine	Angiotensin, Nifedipine, Heart Failure, Hypertension, Myocardial Infarction	Indication Indicated	Indication Indicated	Indication Indicated
Quinidine	Angiotensin, Quinidine, Heart Failure, Hypertension, Myocardial Infarction	Indication Indicated	Indication Indicated	Indication Indicated
Verapamil	Angiotensin, Verapamil, Heart Failure, Hypertension, Myocardial Infarction	Indication Indicated	Indication Indicated	Indication Indicated

Pharmaceutical Intelligent Information System



PROPERTY BROWSER

For Project: **pis_amplado** For Project: **pis_amplado**

Associated Hierarchy

- owl:Thing
 - Adm-gc
 - Drug
 - Patient

Object Datatype Annotation All

Datatype Properties

- Indication
- ActiveIngredient
 - ADose
 - ADoseMax
 - ADoseOral
 - ADoseRectal
- ActiveIngredientCompatible
- PatientName
- ATC
 - ATCAI
- PatientAllergic
 - SideEffects
 - SideEffectsATC
- DrugDose
 - AllergicName
 - AllergicIngredientID
 - AllergicIngredient
 - DrugInteraction

JessTab



Rule	Jess Rule
Drug Interaction Rule	<pre>(define rule1 (object (is-a http://PIS_amplado.owl#Drug (object 741) (http://PIS_amplado.owl#ActiveIngredient 740)) (object (is-a http://PIS_amplado.owl#Drug (object 742) (http://PIS_amplado.owl#ActiveIngredient ncompatible 740)) (test (= (741 740)) => (printoutt "Drug Interaction found"))))</pre>
Allergy Interaction Rule	<pre>(define rule2 (object (is-a http://PIS_amplado.owl#Drug (object 741) (http://PIS_amplado.owl#ActiveIngredient 740)) (http://PIS_amplado.owl#PatientAllergic 740)) (test (= (741 740)) => (printoutt "Allergy Interaction found")))</pre>
Drug Loop Rule	<pre>(define rule3 (object (is-a http://PIS_amplado.owl#Drug (object 741) (http://PIS_amplado.owl#SideEffect 740)) (object (is-a http://PIS_amplado.owl#Drug (object 742) (http://PIS_amplado.owl#Indication 740)) (test (= (741 740)) => (printoutt "Drug Loop found")))</pre>

Patient Health RFID Card

Memory Map	
"Patient Start: 0x0....	4bytes
"Patient End: 0x0....	4bytes
"Active Start: 0x0....	4bytes
"Active Ingredient End: 0x0....	4bytes
"Allergic Ingredient Start: 0x0....	4bytes
"Allergic Ingredient End: 0x0....	4bytes
"Allergic Start 0x0....	4bytes
"Allergic End 0x0....	4bytes
"Drug Start: 0x0....	4bytes
"Drug End: 0x0....	4bytes
"Side Effect Start 0x0....	4bytes
"Side Effect End: 0x0....	4bytes

Active Ingredient	Patient
"ID: 0x0....	"ID: 0x0....
"Name: 0x0....	"Name: 0x0....
"Allergic Address: 0x0....	"Surname: 0x0....
"ID: 0x0....	"Age: 0x0....
"Allergic: 0x0....	"Weight: 0x0....
"Name: 0x0....	"Height: 0x0....
"Dose: 0x0....	"ID: 0x0....
"Drug Address: 0x0....	"ID: 0x0....
"ID: 0x0....	"ID: 0x0....

Drug	Allergic Ingredient
"ID: 0x0....	"ID: 0x0....
"Name: 0x0....	"Name: 0x0....
"Dose: 0x0....	"Dose: 0x0....
"Drug Address: 0x0....	"Drug Address: 0x0....
"ID: 0x0....	"ID: 0x0....

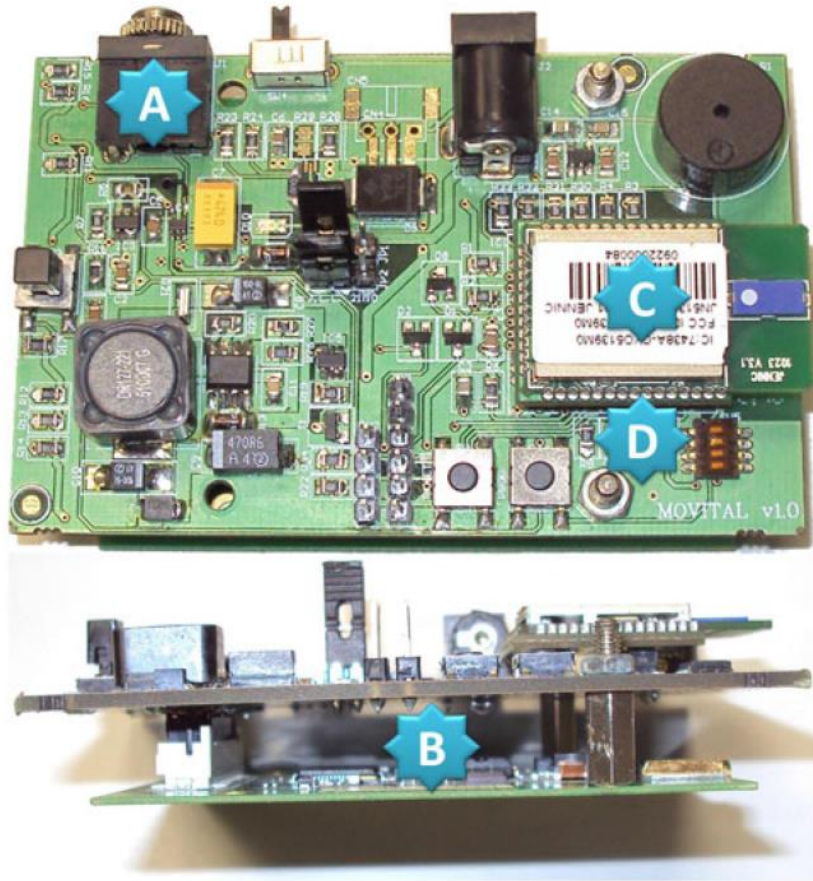
Side Effect	Side Effect
"ID: 0x0....	"ID: 0x0....
"Name: 0x0....	"Name: 0x0....
"Dose: 0x0....	"Dose: 0x0....
"Drug Address: 0x0....	"Drug Address: 0x0....
"ID: 0x0....	"ID: 0x0....



Identification technologies

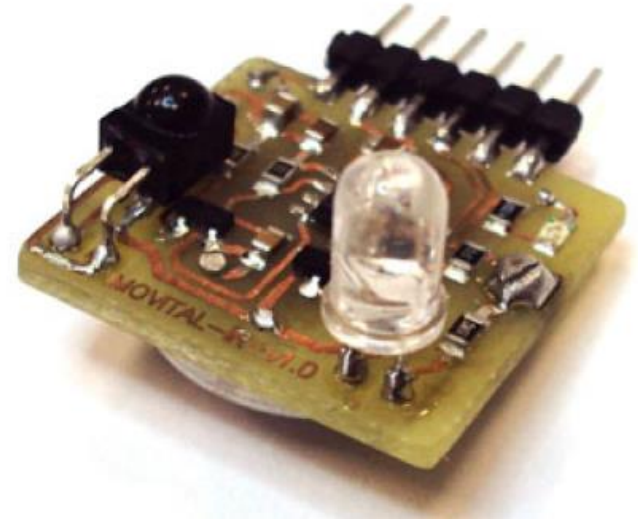
- Barcode
 - Free; 12 Bytes max
- RFID/NFC
 - Up to 4096 Bytes; Integration with smartphones
- IrDA TBTtag
 - 16 Bytes; Low-income countries

Movital RFID



Movital IrDA

- TB in cooperation with WHO



RFID for Drug Stores



Pharmaceutical Intelligent Information System

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Drug data

Active ingredients

ACIDO ACETILSALICILICO, 500 MILIGRAMOS
MALEAT CLORFENAMINA, 1.41 MILIGRAMOS
TARTRATO FENILEFRINA, 8.21 MILIGRAMOS

Side effects

Side effects of aspirin stem from the mechanism of action. One of the most prominent side effects is gastrointestinal problems. This occurs because of the inhibition of the formation of prostaglandin, one of the functions of which is to help form a protective mucus layer around the stomach lining. Other side effects of aspirin include bleeding, kidney failure, ringing in the ears and hearing loss, but these are more common at higher doses. Aspirin should generally not be used in children unless otherwise advised by a health care professional, as it can cause a deadly disease called Reye's syndrome.

Drug information

Renal

Pregnancy

Name: Aspirin



Edit

Drug Interactions

Acenocoumarol	Ibuprofen
Acetazolamide	Insulin
Acetohexamide	Insulin-aspart
Anisindione	Insulin-detemir
Betamethasone	Insulin-gargine
Chlorpropamide	Insulin-gulisine
Cortisone acetate	Insulin-lispro
Dexamethasone	Ketorolac
Dichlorphenamide	Methazolamide
Dicoumarol	Methotrexate
Fludrocortisone	Methylprednisolone
Ginkgo biloba	Paramethasone
Glibenclamide	Prednisolone
Gliclazide	Prednisone
Glipizide	Probenecid
Glioxepide	Sulfingyrazone
Glycodazine	Ticlopidine
Griseofulvin	Tiozamide
Heparin	Tolbutamide
Hydrocortisone	Tramandione
	Valproic Acid
	Warfarin

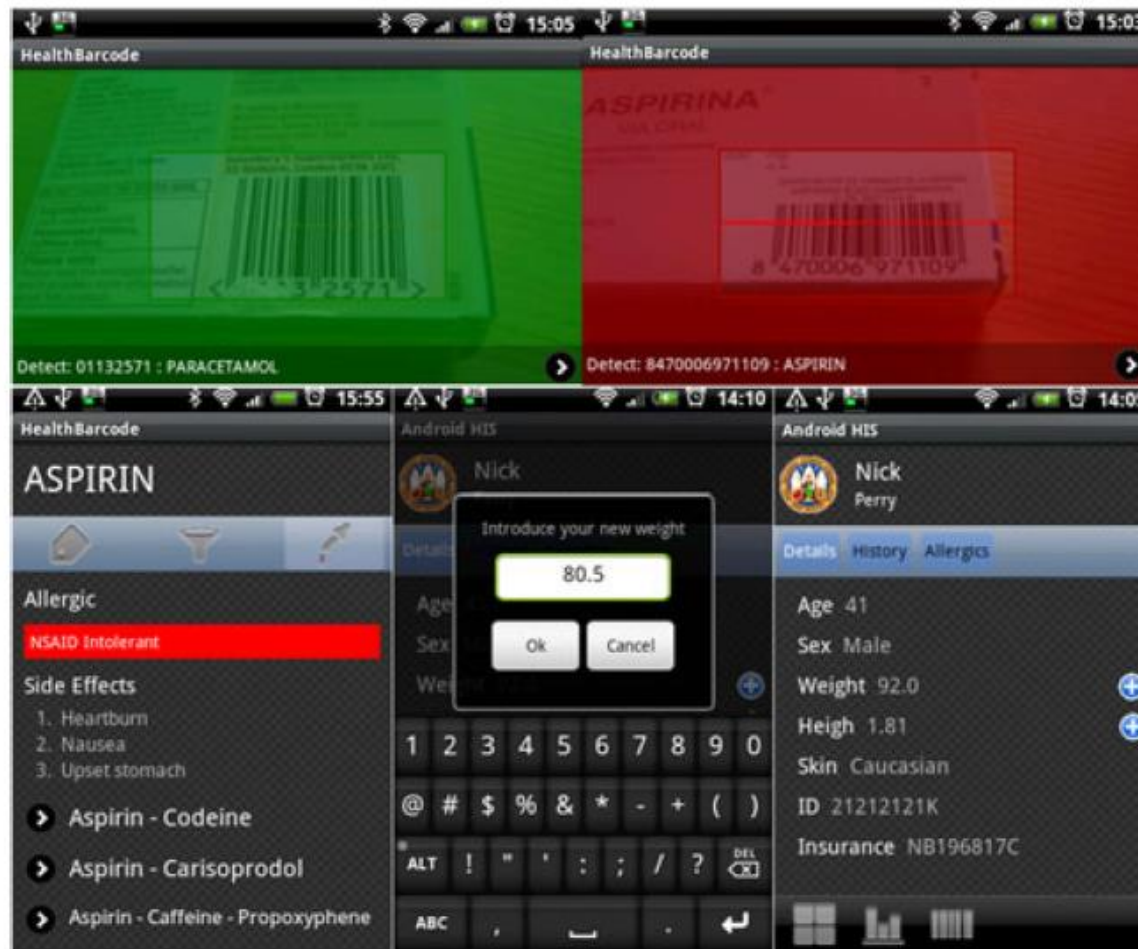


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RFID + Barcode for Smartphones



RFID + Barcode for Smartphones (cont.)



RFID + Barcode for PDA



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CODE: 6559567	Therap. gr.: NO2BE	Labs RIMAFAR												
<p>Paracetamol is a p-aminophenol derivative that exhibits analgesic and antipyretic activity. It does not possess anti-inflammatory activity. Paracetamol is thought to produce analgesia through a central inhibition of</p>														
<table border="1"> <thead> <tr> <th>Active Ingredients</th><th>Qty.</th><th>Units</th></tr> </thead> <tbody> <tr> <td>Paracet</td><td>1</td><td>g.</td></tr> <tr> <td>Aspartame (E-951) (Exc)</td><td></td><td></td></tr> <tr> <td>Sodium, Salt (Exc)</td><td>38.8</td><td>mg.</td></tr> </tbody> </table>			Active Ingredients	Qty.	Units	Paracet	1	g.	Aspartame (E-951) (Exc)			Sodium, Salt (Exc)	38.8	mg.
Active Ingredients	Qty.	Units												
Paracet	1	g.												
Aspartame (E-951) (Exc)														
Sodium, Salt (Exc)	38.8	mg.												
<p>reaction to paracetamol (or any of the other ingredients in the product)</p> <p>PRECAUTIONS Paracetamol should be used with caution in patients with:</p>														
Description	Composition	Other Info												
INCOMPATIBILITIES														
Menu														



Conclusion

- Get IoT into the picture
- Use open standards / avoid proprietary protocols – interoperability
- Take care of privacy and security
- Make it affordable
- Help the patients to get through easily and safely



Q&A?
Thank you!