Integrated City Operation Center : An Architecture Case Study with ADD & Data Flow Analysis

SATURN, 2007
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Introduction

- This is a system of systems software architecture design case based on Samsung SDS architecture design process with ADD and data flow analysis.
- The goal of this presentation is to give illustration and lesson from the architecture design process of u-City ICOC software platform

u-City Concept

- Ubiquitous City is an intelligent next-generation city based on u-IT (Ubiquitous Information Technology)
  - Dozens of u-City are planed by the Korean Government

u-Education | u-Health | u-Crime Prevention | u-Disaster Prevention

u-Environment | u-R&D | u-Facility | u-Traffic

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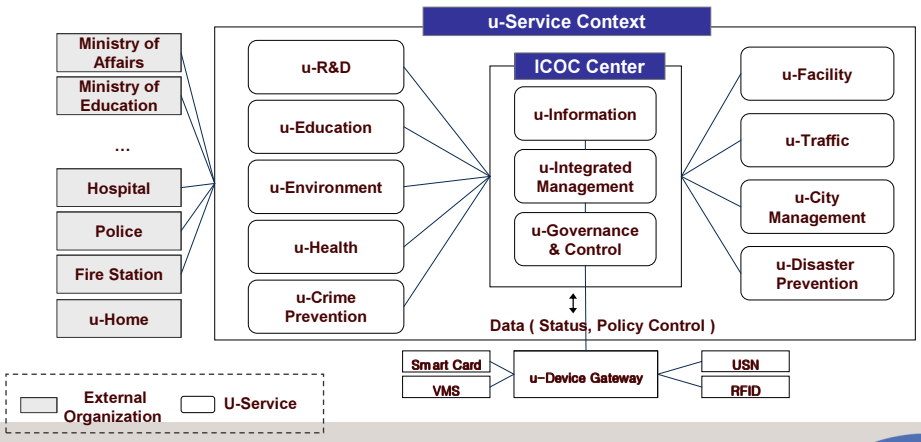
Integrated City Operating Center

- ICOC is core system for u-Service operation and governance
- ICOC is Interoperation backbone of distributed & separated u-Services
- ICOC software platform would be a core competency of Samsung SDS



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Architecture Goal & Challenge

Case Overview

- Architecture Design Goal
  - ICOC architecture design for software solution development
  - Define software platform and identify core modules for business competency
- Challenge
  - No reference architecture & concept only
  - Broad concept & lack of detail functionality
  - Rapid change of ubiquitous Technology
  - Ambiguous system role
  - Seamless integration with external partner
  - System implement time is obscure

Architecture Process

Architecture Driver

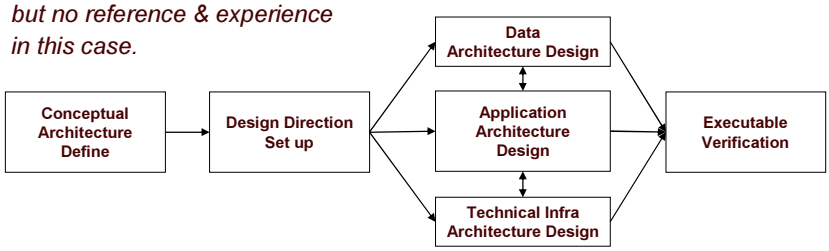
Architecture Design Approach

Arch.Process

- Conceptual Architecture First.
  - Focus on system direction and scope with conceptual architecture
- Based on SDS architecture design process with ADD
  - Phased architecting process for system of systems
  - ADD merged with SDS architecture design process
- Data Flow Analysis as a supplementary technique
  - To derive system function
  - To define & verify role of internal module
- Architecture designed according to the u-City road-map
  - Realistic feasible architecture for short-term
  - Additional long-term future architecture as a vision

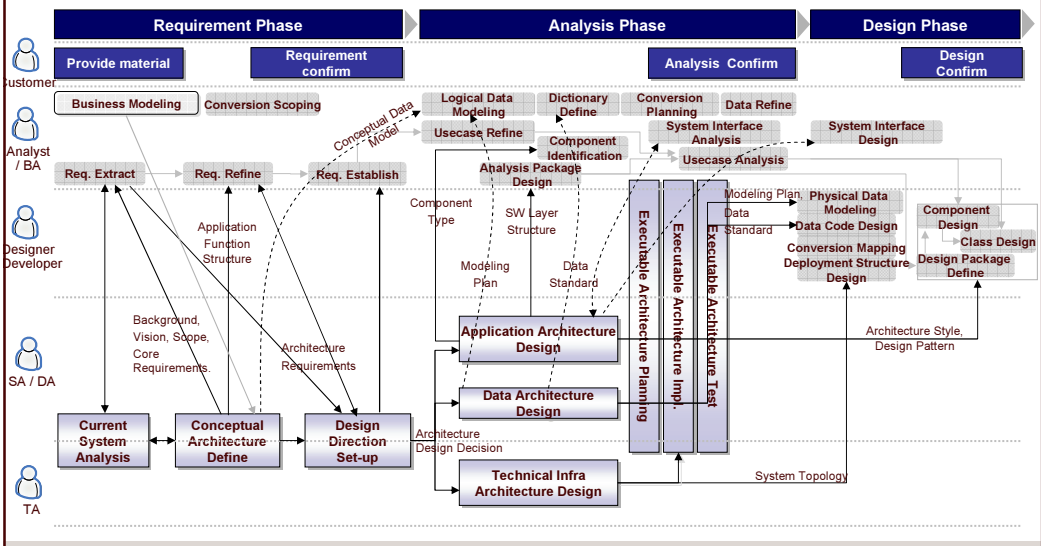
SDS Architecture Design Process

- Designed for system integration project
- Focused on system of systems
- Phased approach from conceptual to actual design
- Verification with executable architecture
- Integrated with development methodology
- Experience and reference based
  - *but no reference & experience in this case.*



SDS Architecture Design Process

Arch.Process



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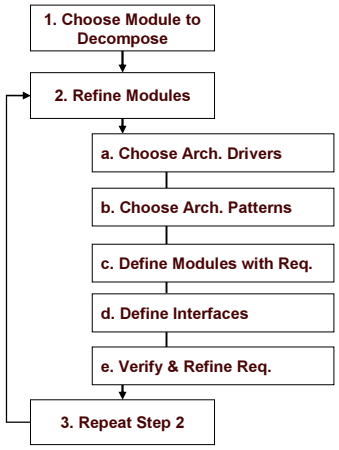
Adopting ADD

- Why ADD
  - Rational process to define software architecture
- ADD
  - Architecture design process
  - Quality scenario based
  - Functional requirement Necessary
  - Providing architecture decisions
  - Define interface to child modules
- ICOC Issues with ADD
  - Insufficient functional requirement to instantiate module
  - System of Systems needs additional design effort due to many design issues



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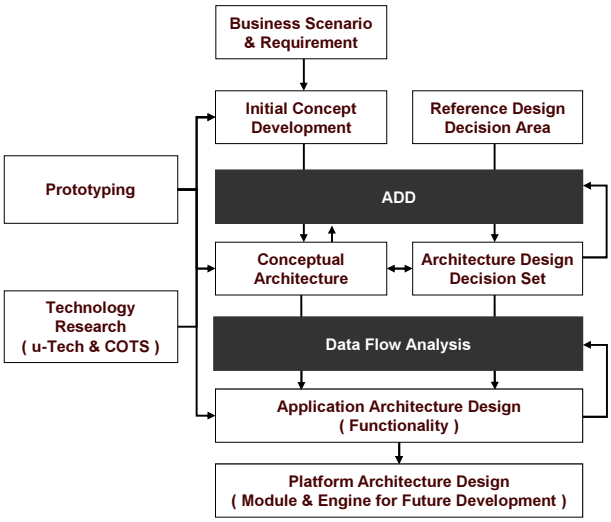
Tailored Architecture Design Process



- **Process**
  - SDS architecture design process to design application architecture
  - ADD merged
  - Data Flow Analysis for compensation
- **Input**
  - Prototyping Result.
  - Technology Research
  - Business Scenario
- **Output**
  - Application Architecture
  - Platform Architecture

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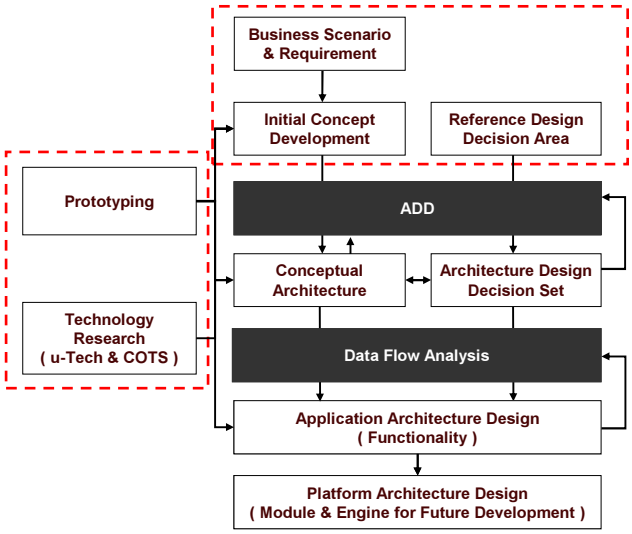
Phase 1 - Preparing Architecture Design



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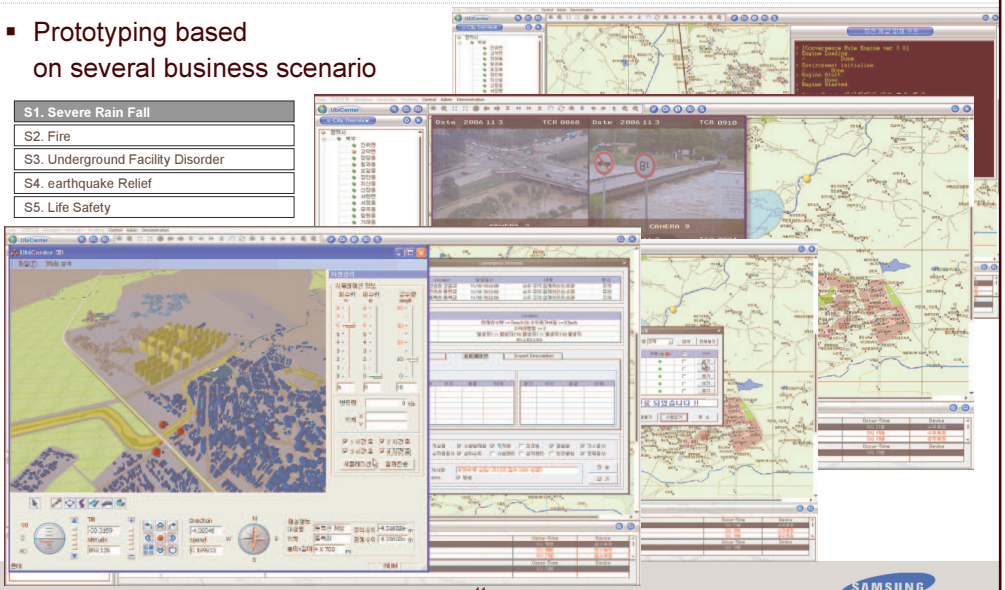
Prototyping

Phase 1

- Prototyping based on several business scenario

S1. Severe Rain Fall
S2. Fire
S3. Underground Facility Disorder
S4. earthquake Relief
S5. Life Safety



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Technology Research

Phase 1

- Enumerate & evaluate related COTS & u-Technology standard
- Research done concurrently with architecture design process

Category	COTS
UI/Presentation	Web Server
UI/Presentation	Enterprise Portal
UI/Presentation	GIS
UI/Presentation	X-Internet
Application	Web Application Server
Application	TP Monitor
Application	Business Rule Engine
Application	Business Process Management Engine
Application	Interference Engine (Rule Engine)
Application	Streaming Service
Data	Meta Data Management Solution
Data	(Disk Based) DB
Data	Main Memory DB
Data	Reporting
Integration	Channel Integration Solution
Integration	Enterprise Service Bus
Integration	Data Integration
Integration	Sensor Network Integration
System Infra	System Management Software
Security	Single Sign On
Security	Network Security
Security	Enterprise Security Management
Etc.	Broad Casting to Citizen (IT Poll)

Category	Standard Technology
Application	ALE (Application Level Event)
Application	BPEL (Business Process Execution Language)
Application	BPEL4WS
Application	BPMN
Web Service	ebXML
Network	BcN (BroadBand Convergence Network)
Network	USN (Ubiqutos Sensor Network)
Network	PLC (PowerLine Communication)
PAN	Zigbee
PAN	BinaryCDMA
PAN	UWB (Ultra Wide Band)
Network	RFID (Radio Frequency Identification)
Mobile	Wi-MAX(Worldwide Interoperability for Microwave Access)
Mobile	Wibro (Wireless Broadband Internet)
Network	Mesh Network
Network	IPv6
Network	IP TV
Network	VOIP
Communication	SOAP (Simple Object Access Protocol)
Communication	JMS (Java Message Service)
Streaming	MPEG 2,4,7

Product Candidate | Utilization Plan | Comparison

Definition | Status | Utilization Plan

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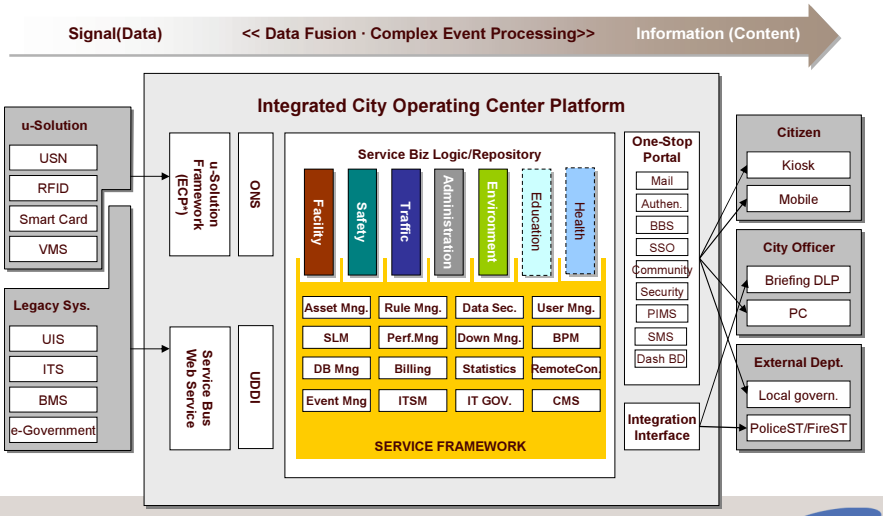
System Concept – Initial

Phase 1

- Starting Point of ICOC Architecture



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Reference Design Decision Area

Phase 1

- Pre-defined design decision area for System of Systems
  - Given set of SDS architecture process and tailoring is necessary

Design Category	Design Decision Area
User Interface	Portal
	Client Technology
	User Environment (Client)
Application Structure	Layer Structure / Design
	Transaction
	Data Access Method
	Common Functionality
	Application Framework
	Batch Job Control
Data	Data Distribution/Integration
	Data Interface
	Data Structure
	Statistics & Reporting

Design Category	Design Decision Area
Integration	Integration Structure
	Interfacing Data Transform
	Integration Flow Control
	Integration Technology
Technical Infra	System Structure
	System Software
	Server Consolidation
	Storage Structure
	Network Topology
Generic Solution	Security Solution
	Rule Engine
	Reporting & OLAP
	EAI & ETCL
Operation & Maintenance	System Management
	Application Management
	Data Management
	Backup & Recovery

A Design Decision Template

Category	Design Area
Issue	
Coverage	
Rel. Req. ID	
Design Decision	
Design 1)	
Design 2)	
Rationale	
Assumption	

Category	Design Area
Issue	
Coverage	
Rel. Req. ID	
Design Decision	
Design 1)	
Design 2)	
Rationale	
Assumption	

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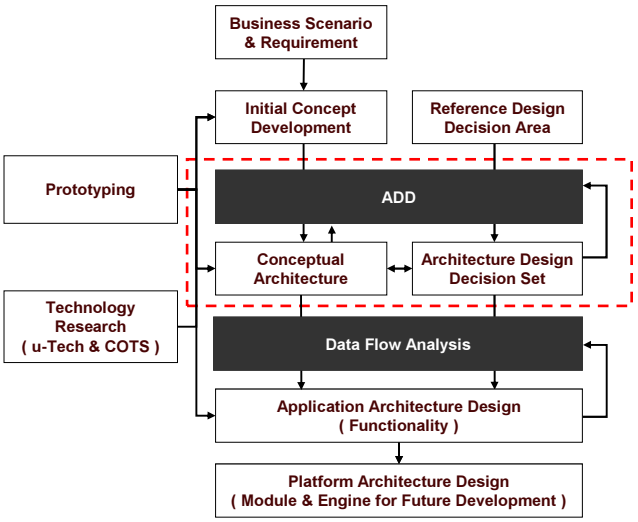
Phase 2 – ADD & Conceptual Architecture



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Applying ADD – 1/2

Phase 2

- ADD applied to design conceptual architecture only

Step	Activity	Related Artifact	Approach
Step #1	Choose the module to decompose	System Concept	
Step #2	Refine the module according the following steps		
2.A	Choose the architecture drivers.	Business scenario Quality Scenario	
2.B	Choose an architecture pattern that satisfies the architecture drivers.	Service Oriented Architecture Black Board	
2.C	Instantiate modules and allocate functionality	Sub-System Define	High Level Only
2.D	Define interfaces of the child modules.	Conceptual Architecture	Service Oriented Design
2.E	Verify and refine use cases and quality scenarios	Business Scenario instead of use-case	
Step #3	Repeat the steps above if necessary		Only Once

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Applying ADD – 2/2

Phase 2

Quality Attribute	Quality Scenario	Priority & Difficulty	Quality Tactics
Performance	Supporting huge amount of u-Device information (~ 100000 tps)	H, H	Layered Information Filtering Separated Hi-Speed Data Transfer Hub MMDB based Real-time Information Storage
Performance	City Status Information updated Real-time (1 Minute)	H, H	Separated Hi-Speed Data Transfer Hub MMDB based Real-time Information Storage
Modifiability	Addition External Organization integration without Re-Development	H, M	Service Oriented Architecture Standardized ICOC Service Providing Centralized City Information Data
Modifiability	Additional u-Device without System Re-Development	M, L	Separating Layering of device control
Modifiability	Additional u-Service without System Re-Development	M, M	Information & ICOC Service Registry with ESB
Availability	Facility management functionality must operate even if ICOC center failure	H, M	Independent Facility Management System Remote Operation Interface
Usability	City Status Information must be visualized as 3D when Facility Status Change	M, H	Facility Status Change Event Notification with Direct Access to Status DB
Usability	City Facility must be controllorable directly within 3D status monitoring Screen.	L, H	Provide Facility Management Interface on the monitoring Client
Usability	Support Facility Control on the spot with Mobile Device	M, H	PDA based Facility management Service with WiFi or CDMA
Performance	Relevant u-Device Data must be routed to registered u-Service	H, M	Configurable routing of u-Device Data

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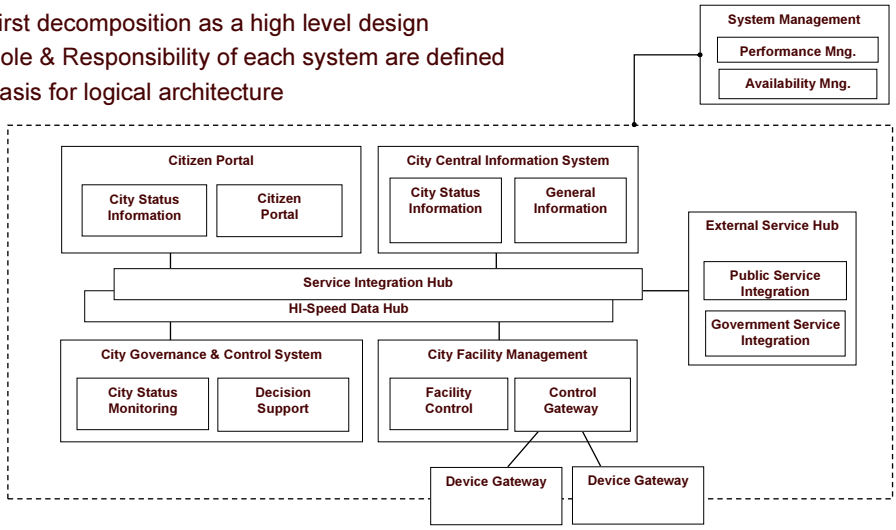
Conceptual Architecture

Phase 2

- First decomposition as a high level design
- Role & Responsibility of each system are defined
- Basis for logical architecture



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Architecture Design Decision Set

Phase 2

- Decision set modified with conceptual architecture
- Key design decision by the ADD
- Other design decision from requirement & experience

Quality Tactics

Performance Tactic
Modifiability Tactic
Availability Tactic
Usability Tactic

System Req.

Integrated Operation
Remote Facility Management
Citizen Portal
City Information Monitoring

Design Category	Design Area
Application Structure	Common Functionality
	Layer Structure / Design
	Transaction
	Data Access Method
	Application Framework
	Batch Job Control
User Interface	Portal
	Client Technology
	User Environment (Client)
Integration	Integration Structure
	Interfacing Data Transform
	Integration Flow Control
	Integration Technology
Data	Data Distribution/Integration
	Data Interface
	Data Structure
Solution	GIS
	Streaming
	Rule Engine

Category	Integration	**Design Area**	Integration Structure
Issue	Integration Topology among sub-systems.		
Coverage	Whole System		
Rel. Req. ID	ARCH_REQ_4,5,10	**Rel. QS**	QS 3,5
Design Decision	1) HUB integration – Integration with Central Integration Hub		
	2) P2P Integration – Peer to Peer Direct Access		
	3) Hybrid Design with Hub & P2P		O
1) Hub Integration	Central Integration Hub (ESB) operates as a Integration method.		
2) P2P integration	Peer to peer direct connection for each sub-system.		
Rationale	Event & u-Device Data within u-City must be delivered several system simultaneously, hub structure is better choice for simplifying data message delivery structure. Routing path is difference according to Message Contents & priority, so that hub integration with flexible routing is necessary. For intensive status data access to central information database, direct DB access is most economic way.		
Assumption	ESB provides contents based routing functionality.		

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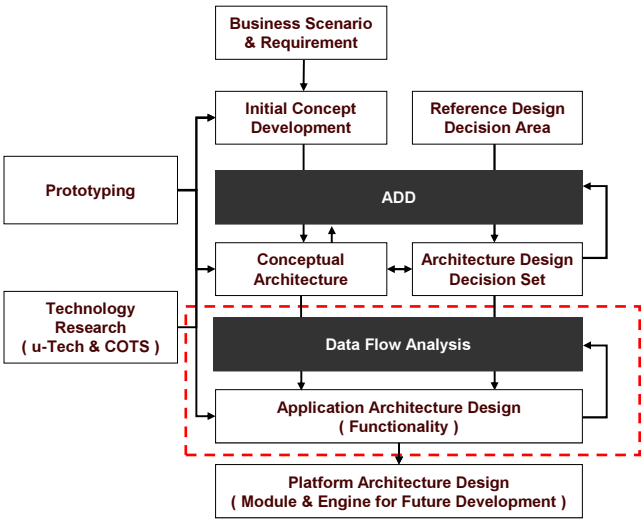
Phase 3 - Detail Architecture Design



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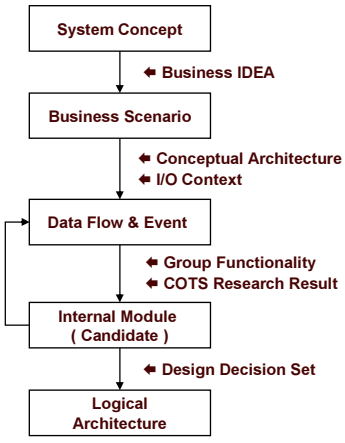
Data Flow Analysis - 1/2

Phase 3

- DataFlow Analysis
  - Business scenario based
  - Consider how business scenario resolved on the conceptual architecture
  - Find functionality within data flow & event
  - Group functionality and refine internal module

  % Informal Process with Insight

- Usage
  - Internal module is the basis for logical architecture
  - Assign internal module to conceptual architecture with design decision set



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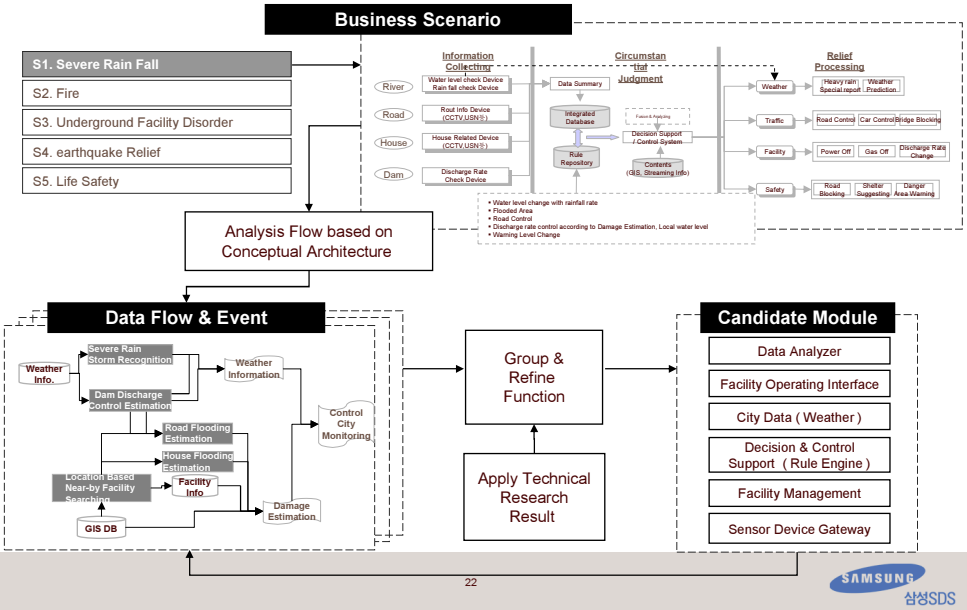
DataFlow Analysis – 2/2

Phase 3



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Application Architecture

Phase 3

- Application Architecture
  - Architecture representing system's internal structure at application level.
  - Second decomposition of ICOC architecture
  - Focused on system's role & functionality
  - Does not contains specific COTS information

- Application Architecture Design
  - Based on conceptual architecture
  - Allocate & refine candidate module with design decision set

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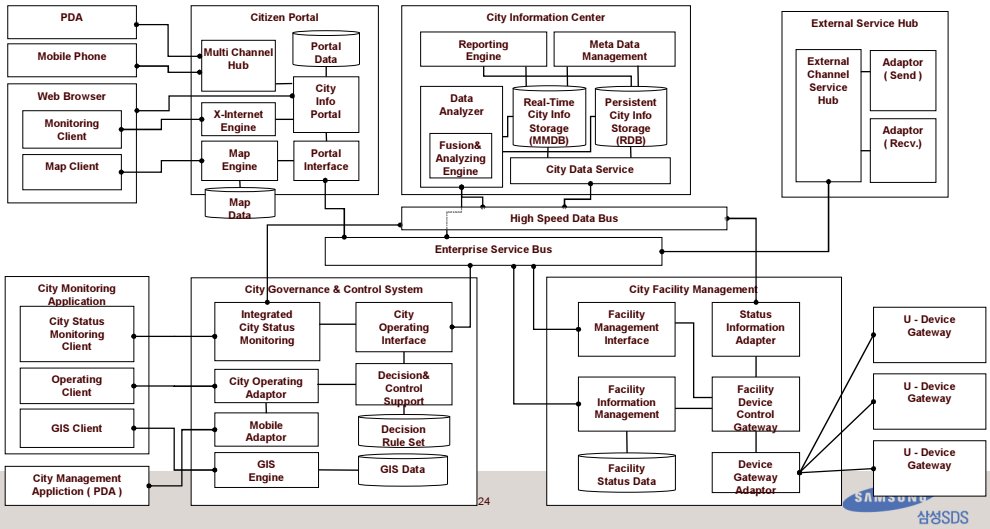
Logical View – High Level Module View

Phase 3

- Second level decomposition
- Represent system functionality with sub-system & its relation



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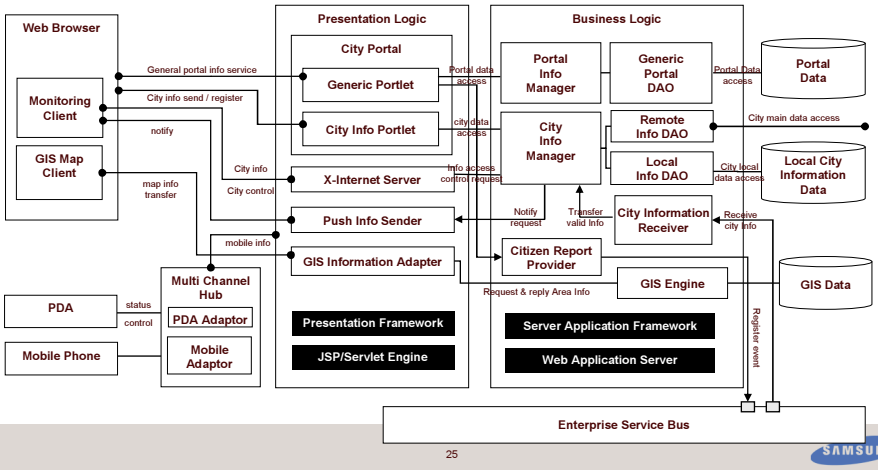
Logical View – Detailed C&C View

Phase 3

- Third decomposition of citizen portal
- Designed by referencing generic portal architecture
- Software components and relationships were identified clearly at this level



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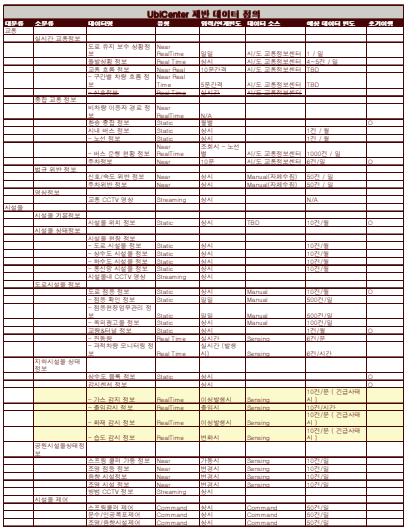
Verification - Feasibility Study

Phase 3

- Extension of data analysis
- Identify all possible input data at current city environment
- Estimate feasibility of architecture by evaluating data processing path
- Investigated input data property
  - Data Name
  - Data Type
  - Transaction Frequency
  - Update Frequency
  - Data Source
  - Initialization Support



UbiCenter 제안 데이터 정의

대분류	소분류	데이터명	정의	업데이트	데이터 소스	예상 데이터 양도	초기여부
교통	실시간 교통정보						
		도로 유지 보수 상황 정보	Near RealTime	필요	AI/도 교통정보센터	1 / 일	
		돌발상황 정보	Real Time	실시	AI/도 교통정보센터	4~5건 / 일	
		주변 차량 정보	Near Real Time	1초간격	AI/도 교통정보센터	TBD	
		주간별 차량 초동 정보	Near Real Time	5분간격	AI/도 교통정보센터	TBD	
		버스정보	Real Time	실시간	AI/도 교통정보센터		
	통합 교통 정보						
		버스정류장 교통 정보	Near RealTime	실시			
		환승 종점 정보	Static	필요			O
		지하철 정보	Static	실시		1건 / 월	
		노선 정보	Static	실시		1건 / 월	
		버스 간변 운행 정보	Near RealTime	도로시 ~ 노선별	AI/도 교통정보센터	1000건 / 일	
		주차정보	Near	대로	AI/도 교통정보센터	6건/일	O
	법규 위반정보						
		신호/속도 위반 정보	Near	실시	Manual(자동수집)	60건 / 일	
		주차위반 정보	Near	실시	Manual(자동수집)	60건 / 일	
	영상정보						
		교통 CCTV 영상	Streaming	실시		N/A	
시설물							
	시설물 기본정보						
		시설물 위치 정보	Static	실시	TBD	10건/월	O
	시설물 상태정보						
		시설물 위치 정보					
		- 도로 시설물 정보	Static	실시		10건/월	
		- 상수도 시설물 정보	Static	실시		10건/월	
		- 하수도 시설물 정보	Static	실시		10건/월	
		- 옥외광고물 정보	Static	실시		10건/월	
		시설물내 CCTV 영상	Streaming	실시			
	도로시설물 정보						
		도로 정류 정보	Static	실시	Manual	10건/월	O
		- 정류 확인 정보	Static	실시	Manual	600건/일	
		- 정류환승정보관리 정보	Static	실시	Manual	600건/일	
		- 옥외광고물 정보	Static	실시	Manual	100건/일	
		- 지하상가 정보	Static	실시		1건/월	O
		- 차량정	Real Time	실시간	Sensing	6건/분	
		- 과적차량 모니터링 정보	Real Time	실시간 (발생시)	Sensing	6건/실시간	
	시설시설물 상태정보						
		상수도 블록 정보	Static	실시			O
		맨홀/로 정보	Static	실시			O
		- 가스 감지 정보	RealTime	이상발생시	Sensing	10건/분 (건급시에 시)	
		- 홍수감시 정보	RealTime	홍수시	Sensing	10건/실시간	
		- 화재 감시 정보	RealTime	이상발생시	Sensing	10건/분 (건급시에 시)	
		- 승도 감시 정보	RealTime	변화시	Sensing	10건/분 (건급시에 시)	
	유틸시설물상태정보						
		스포트 클러 가동 정보	Near	가동시	Sensing	10건/일	
		전봇 점등 정보	Near	변경시	Sensing	10건/일	
		화학 시설정보	Near	변경시	Sensing	10건/일	
		주변 시설 정보	Near	변경시	Sensing	10건/일	
		방범 CCTV 정보	Streaming	실시			
	시설물 제어						
		스포트물의 정보	Command	실시	Command	60건/일	
		무단가로주도 정보	Command	실시	Command	60건/일	
		조명/휴게시설제어	Command	실시	Command	60건/일	

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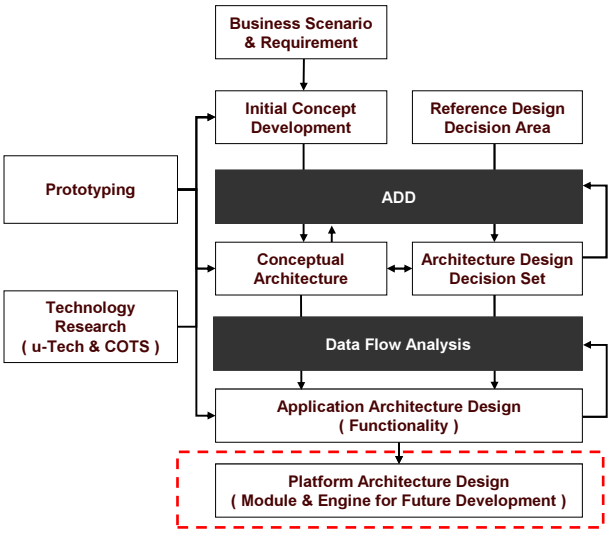
Phase 4 – Platform Architecture



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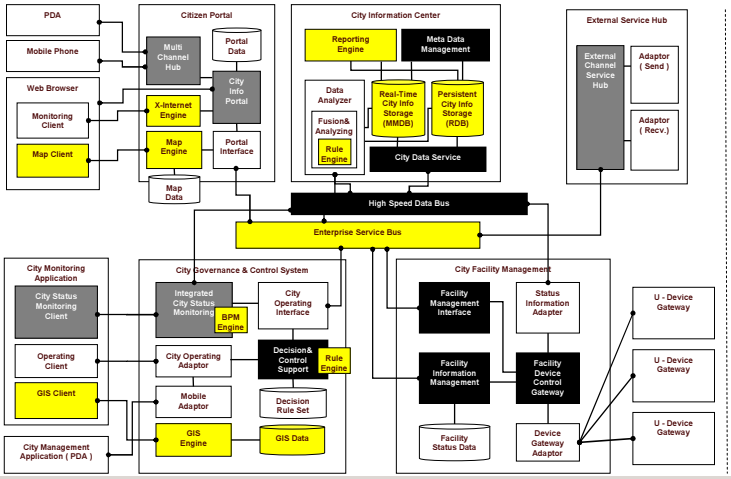
ICOC Platform Design

Phase 4

- Each element are marked as 4 type.
- Identify sub system & core module for future development based on logical architecture



Module **Custom Build**
- Implemented within Project
- Not a part of Platform

Module **Reuse**
- pre-existing company asset

Module **COTS Adoption**
- Evaluation & Bench Marking Necessary

Module **Core module to develop in advance**
- Core competency
- Planed to develop

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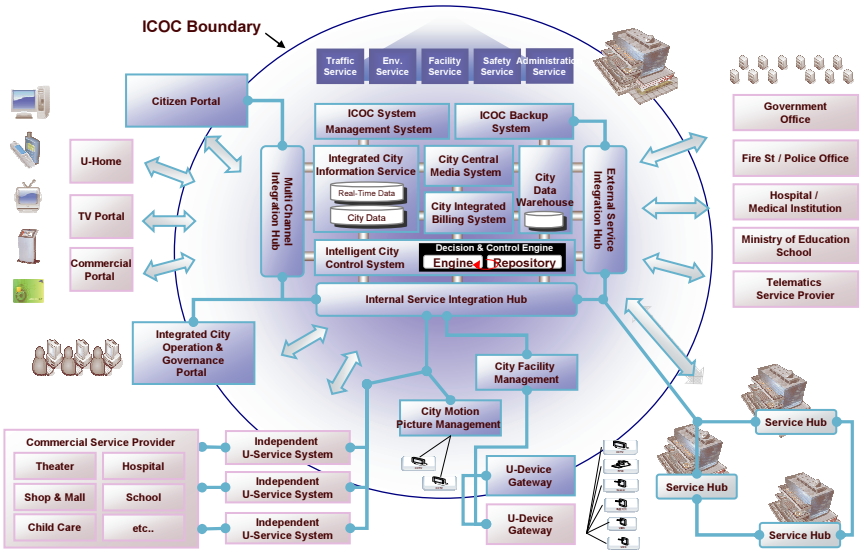
High Level Architecture – Future Model



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Lesson Learned - 1/2

- ADD works on high level
  - Difficult to instantiate module and allocate functionality if requirement are not sufficient
  - Alternative compensation process was necessary to detail architecture design
- System of Systems
  - Conceptual architecture is important for system's direction & scope
  - Many levels of decomposition due to its scale
  - View-type is mixed and not clear at high level design
  - COTS evaluation is critical factor for detail architecture design

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Lesson Learned - 2/2

- Architecture & Requirement
  - Conceptual architecture is a basis for detailed requirement
  - More detailed requirements can be acquired as the architecture become mature
- Data-Flow Analysis
  - Starting from business scenario & context
  - I/O data flow analysis is good tool for define system functionality.
  - Provide smooth connection between architecture & detail design

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Limitation

- It is not a fully implemented system
  - Prototype and only several modules were developed
  - Architecture designed to identify common software component
  - Still many alternatives according to the final selection of COTS
  - Not fully verified as an executable architecture
- Not a strict straight forward design process
  - Go back & forth
- Just a case of what we had done.