Intuitionistic Fuzzy Component Failure Impact Analysis (IFCFIA)

a method for soft SLA dependency mapping and fuzzy impact analysis

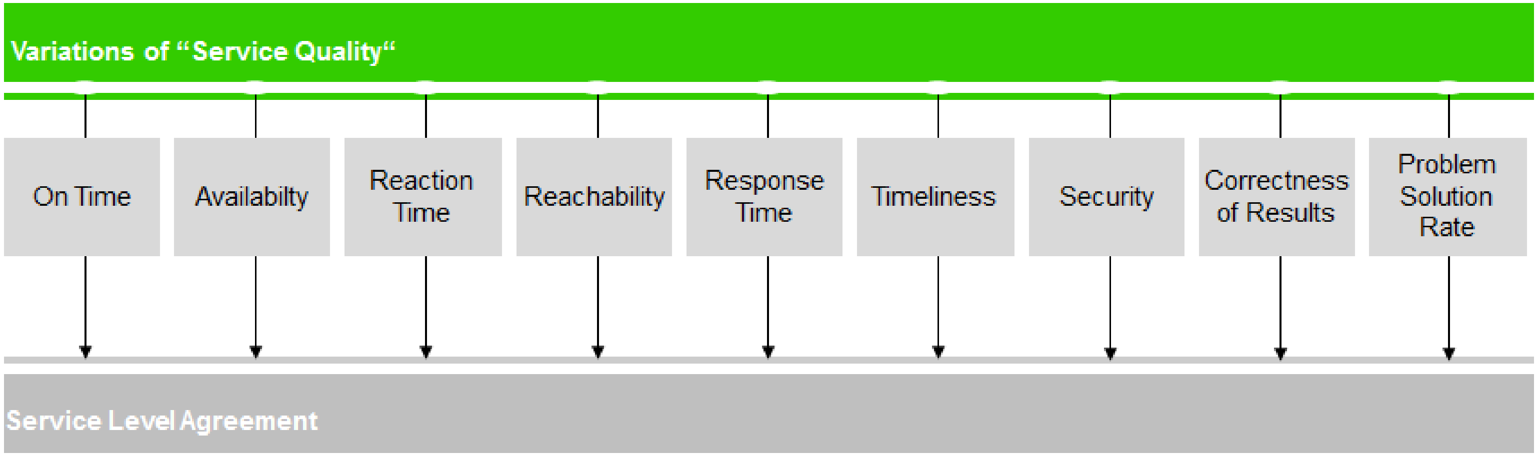
Roland Schütze

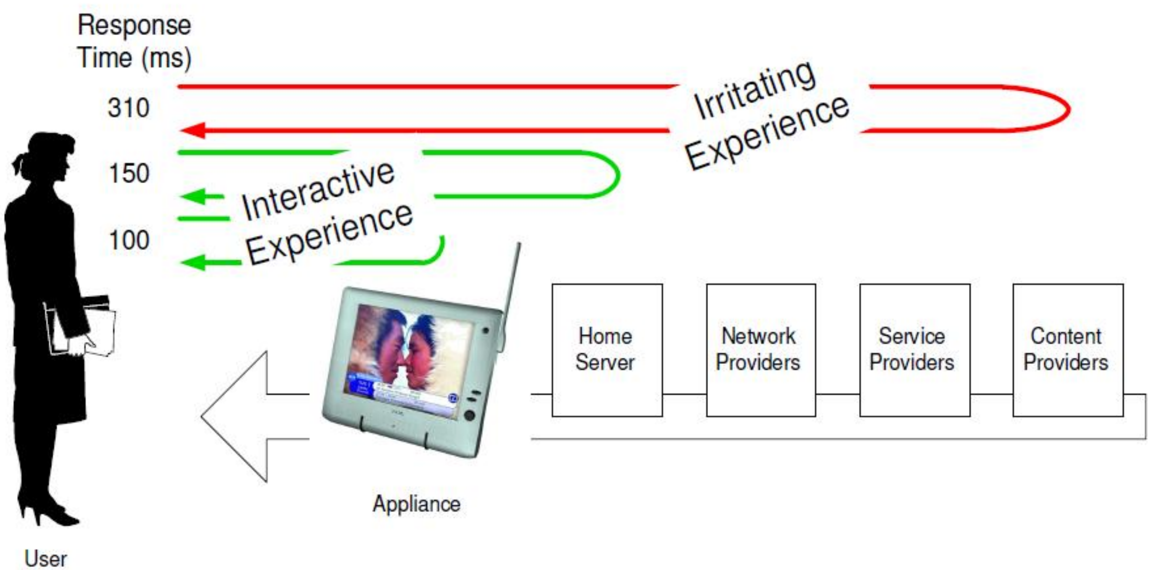
University of Fribourg, Dept. of Informatics, Switzerland

20.10.2013

1. Background and Problem Statement
2. Interdependencies & Couplings
3. Intuitionistic Fuzzy Sets
4. IFCFIA Solution Approach
5. IFCFIA Use Cases

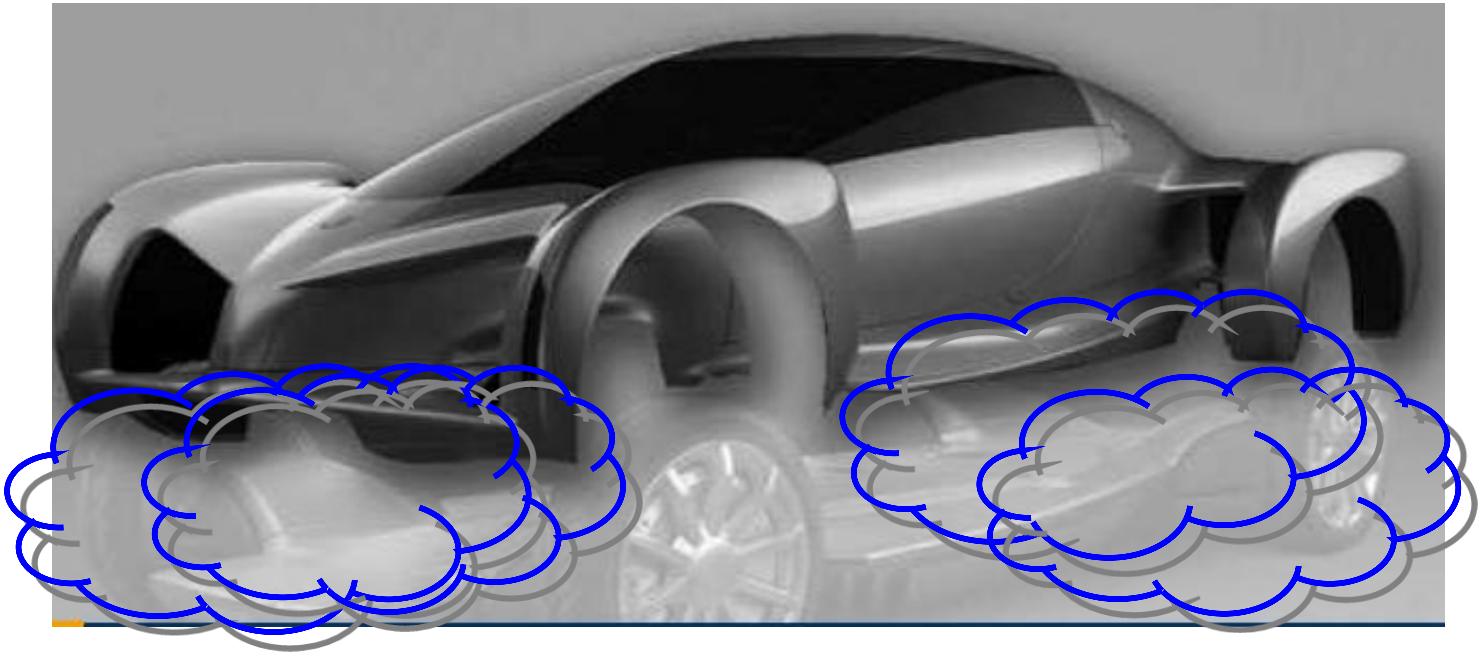
For “Service Quality“ several measurement and delivery criteria can be defined





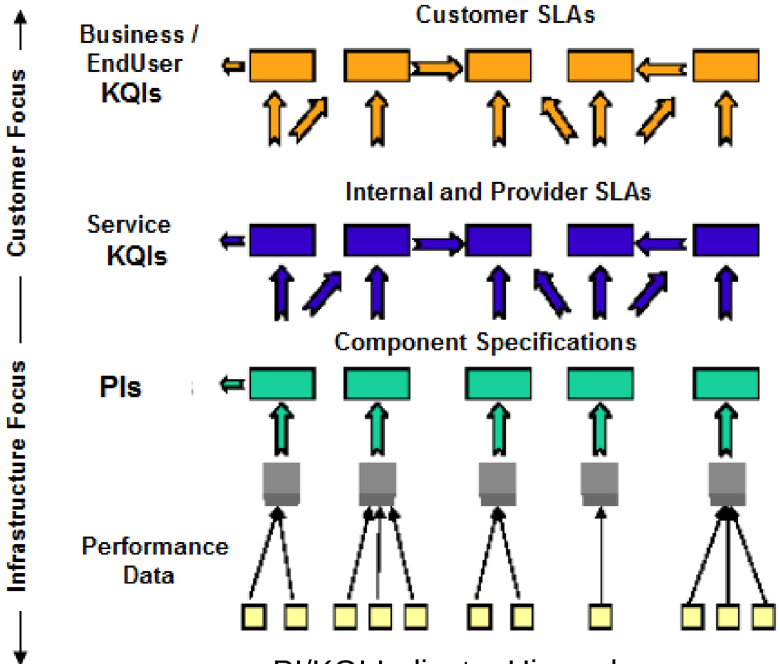
Interactive versus Irritating Experience : aggregated value within a multi-dimensional classification space (Response Time, Picture Quality, Usability, Design etc.)

Challenge of multi-layered SLA translations

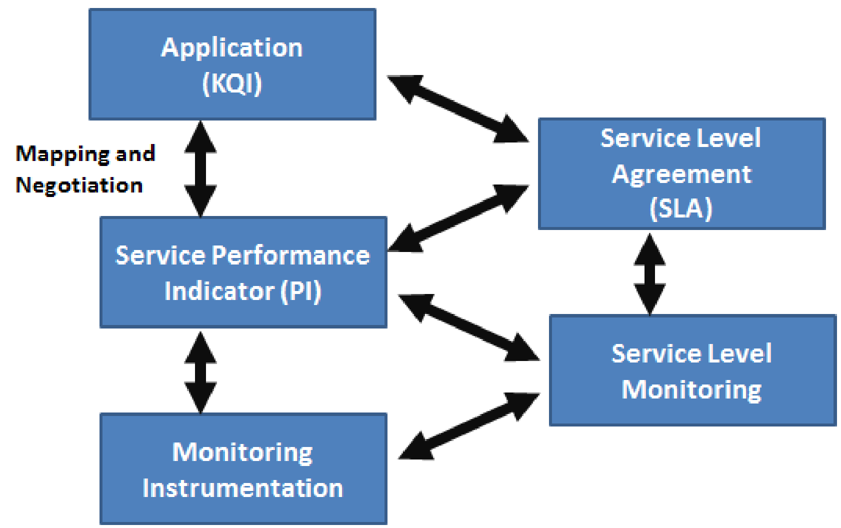


Bridging IT-centric service levels, written in IT technical terms, to business-oriented service achievement is one of the key challenges in todays' Service Management. To guarantee Service Level Agreements (SLAs) it is important to relate metrics for business applications into measurable parameters for technical services that can be defined and reported against a SLA and monitored under Service Level Management. This work defines dependency couplings in a practical and feasible manner in order to satisfy aspects of the distributed nature of SLAs in a multi-tier-architectural environment and offers transparency into complex impact assessments.

The concept of Key Quality - and Performance Indicators
(The Open Group 04)



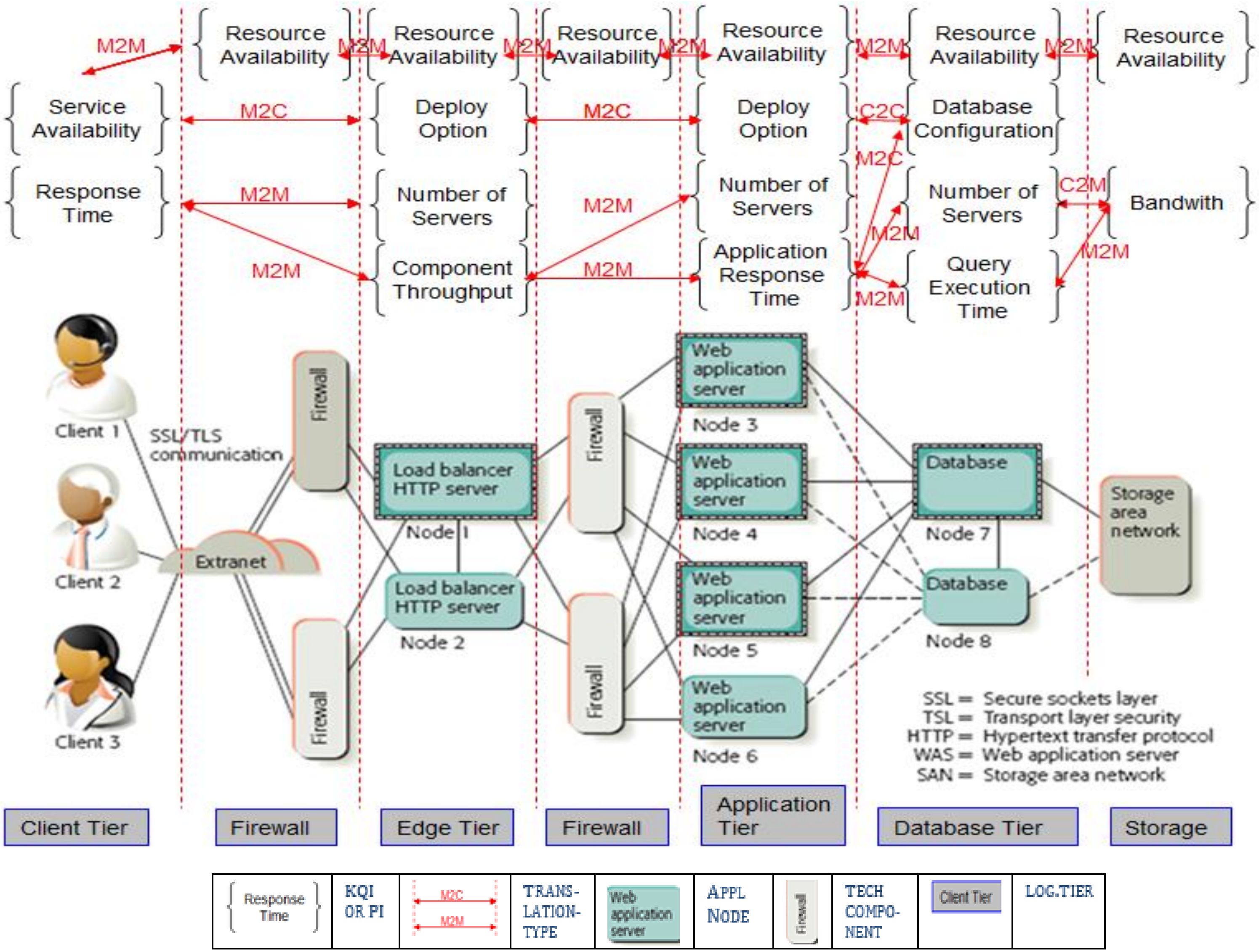
PI/KQI Indicator Hierarchy



KQI , PI, and SLA Relationship [Open Group 04]

Service Level Specification parameters can be one of two types: Key Quality Indicators (KQIs) and (most technical) Service Performance Indicators (PIs). At the highest level, a KQI or group of KQIs are required to monitor the quality of the business service offered to the end-user. These KQIs will often form part of the contractual SLA between the provider and the customer. A KQI provides a measurement of a specific aspect of the performance of a Product or a Service. The KQI is derived from a number of sources, including performance metrics of the service or underlying support services as PI. As a service or application is supported by a number of service elements, a number of different PI may need to be determined to calculate a particular KQI. The mapping between the PI and KQI may be simple or complex, empirical or formal.

Topology of a web application with three-tier server configuration



to guarantee business-focused SLAs results in optimization problem solving across multiple domains (e.g. networking, computer systems, and software engineering). The fulfilment of any higher-level objective requires proper enforcements on multiple resources at several levels.

Agenda

1. Background and Problem Statement
2. Interdependencies & Couplings
3. Intuitionistic Fuzzy Sets
4. IFCFIA Solution Approach
5. IFCFIA Use Cases

Dependency Mapping by determining the level of coupling

Dependence Coupling is a measure that we propose to capture how dependent the component or service is on other services or resources for its delivery. Two new types of a logical relationship are now introduced which expresses the level of inter-dependency between components: ‘is tightly coupled’ and ‘is loosely coupled’.

- Loose coupling indicates that the service does not have to depend on other services or resources to complete delivery of its service. Tight coupling on the other hand indicates that successful delivery of other services or availability of resources is a prerequisite for the completion of a service. When the dependency is between a service and some resource it uses, coupling will essentially be a function
- In general the goal is to build components that do not have tight dependencies on each other, so that if one component were to die (fail), sleep (not respond) or remain busy (slow to respond) for some reason, the other components in the system are built so as to continue to work as if no failure is happening. Loose coupling describes an approach where integration interfaces are developed with minimum assumptions between the sending/receiving parties, Loose coupling isolates the components of an application so that each component interacts asynchronously with the others and treats them as a “black box”. E.g. in the case of web application architecture, the app server can be isolated from the web server and from the database.
- When the dependency is between a service and some resource it uses, coupling will essentially be a function of how often the resource is used. For instance, the dependence of a service on the network layer might be measured by how often it is making a socket call, or how much data it is transferring. For web-services we can examine environmental coupling which is caused by calling and being called. Traditional components are more tightly and statically integrated and measurements are related mostly to procedural programming languages. More advanced are object-oriented coupling measures [8] and further several metrics are proposed to evaluate the coupling level real-time by runtime monitoring, introduced as dynamic coupling metrics.

Dependence coupling as measurement

Fenton and Melton proposed a metric to measure the coupling between two components x and y, which is defined in the equation

$$C(x, y) = i + \frac{n}{n+1}$$

where n is the number of interconnections between x and y and i is the highest (worst) level of coupling type found between x and y using the following table.

Coupling Type	Coupling Level	Modified Definition between components x and y
Content	5	Component x refers to the internals of component y, i.e., it changes data or alters a statement in y.
Common	4	Components x and y refer to the same global data.
Control	3	Component x passes a control parameter to y.
Stamp	2	Components x passes a record type variable as a parameter to y.
Data	1	Components x and y communicate by parameters, each of which is either a single data item or a homogenous structure that does not incorporate a control element.
No Coupling	0	Components x and y have no communication, i.e., are totally independent.

Dynamic Coupling Measurements :
(Quynh, Thang 07 Dynamic Coupling Metrics for Services)

Formula	Explanation
$CBS = \sum_{i \neq j=1..n}^{n} A_i B_j$	Measuring the coupling between services. For service A, CBS metric is calculated based on the number of relationships between A and other services in system.

Formula in Software Engineering due to Dhama : *Service Coupling*

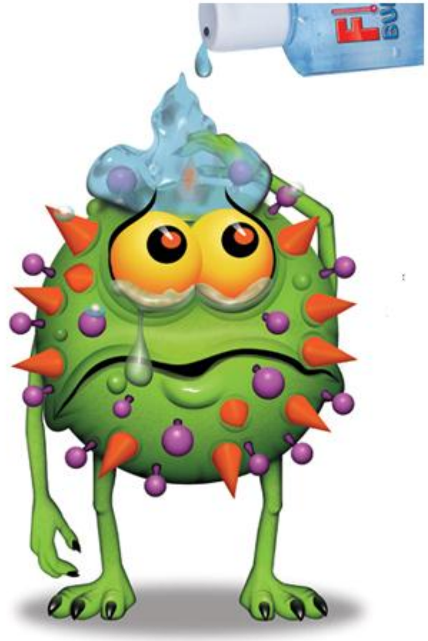
C(x,y) = 1/ (i + u + g + r)
i = in data parameters – data sent from calling service x to called service y
u = out data parameters – data sent from called service y to calling service x.
g = number of global variables
r = number of times x calls y.

The lower this measure, the more tightly coupled the two services are.

Bi-polar Coupling Aspects

Let's discuss this thesis with a simple example. A complex system can on some degree be compared with a human organism. For instance, the possibility or likelihood that a person becomes ill when influenza-infected, results from the combination and intersection of the viral infect attack and the personal immune system stability and recovery ability of the infected individuals. Both of these threads (viral attack and immune system) have opposite effects. When defining something like a "personal influenza disease risk" it does not make sense to consider only one aspect, mostly the infection probability, in isolation. A high risk of infection but with strong immune abilities will not have an impact on the health of the individual person. (in IT terms a business impact). With a strong immune condition "high personal risk of influenza disease" is not necessarily given, even getting the virus infect. The risk getting infected is best described in an inter-modular model (between entities) whereas the immune capabilities are more intrinsic nature (inside an entity)

For a complex IT system this is quiet similar, the risk of infection, are the dependencies through interactions (which can result in an incident), the controversy immune ability are the built-in system resilience capabilities. Both in combination result in the risk of getting a business impact in case an incident somewhere in the system occurs



Further the intelligence in any complex system analysis will be the modelling of the indirect dependencies and interactions. There are several scenarios how an incident may interfere indirectly with other components which is mainly resulting out of the combination of the contrary forces. IT systems try to implement strategies that the resilience capabilities of each component should pro-actively limit the inference and impact of the incident to related components or the business services.

In praxis impacts are complex which constitutes uncertainty. They involve a multitude of effects that cannot be easily assessed and may involve complex causalities, non-linear relationships as well as interactions between effects. This may render it difficult to determine exactly what may happen.

.

Agenda

1 Background and Problem Statement

2 Interdependencies & Couplings

3 Intuitionistic Fuzzy Sets

4 IFCFIA Solution Approach

5 IFCFIA Use Cases

Principle: Extend (not replace) proven ITIL quality engineering.
Failure and Impact Analysis in ITIL v3 Service Lifecycle Modules

- **ITIL Configuration Management Database (CMDB)**
  (Service Transition) A database used to store Configuration Records throughout their Lifecycle. The Configuration Management System maintains one or more CMDBs, which is populated by auto-discovery tools and each CMDB stores Attributes of Configuration Items (Cis), and Relationships with other CIs.
- **ITIL Fault Tree Analysis (FTA)**
  (Service Design) (Continual Service Improvement) A technique that can be used to determine the chain of Events that leads to a Problem. Fault Tree Analysis represents a chain of Events using Boolean notation in a diagram.
- **ITIL Component Failure Impact Analysis (CFIA)**
  (Service Design) A technique that helps to identify the impact of CI failure on IT Services. A matrix is created with IT Services on one edge and CIs on the other. This enables the identification of critical CIs (that could cause the failure of multiple IT Services) and of fragile IT Services (that have multiple Single Points of Failure).
- **ITIL Failure Modes and Effects Analysis (FMEA)**
  This proactive troubleshooting method can be part of a CFIA and allows the engineer to consider how the failure modes of each system component can result in system performance problems and to ensure that appropriate safeguards against such problems are put in place.
- **ITIL Service Failure Analysis (SFA)**
  (Service Design) An Activity that identifies underlying causes of one or more IT Service interruptions. SFA identifies opportunities to improve the IT Service Provider's Processes and tools, and not just the IT Infrastructure.
- **ITIL Root Cause Analysis (RCA)**
  (Service Operation) An activity that identifies the root cause of an incident or problem. RCA typically concentrates on IT infrastructure failures.
- **ITIL Pain Value Analysis (PVA)**
  (Service Operation) An activity used to help identify the Business Impact of one or more Problems. A formula may be defined to calculate Pain Value based on the number of Users affected, the duration of the Downtime, the Impact on each User, and the cost to the Business.
- **ITIL Business Impact Analysis (BIA)**
  (Service Strategy) BIA is the Activity in Business Continuity Management that identifies Vital Business Functions and their dependencies. These dependencies may include Suppliers, people, other Business Processes, IT Services etc. BIA defines requirements which include Recovery Time Objectives, Recovery Point Objectives and minimum Service Level Targets for each IT Service.

IFCFIA – Seven Step Approach

IFCFIA Step 1: Auto-discovery by ADDM tools:
All infrastructure component items and technical dependencies of a defined scope will be auto-discovered using ADDM tools. This provides trust that the discovered information is real by automatically discovering interdependencies among applications and underlying systems and minimize IT organizations expend on the information assimilation. The discovered components with corresponding relations can be extracted by ADDM tools in a structured data format e.g. xml for further automated processing.

IFCFIA Step 2: Defining the Business Service:
The in-scope discovered component items are grouped to form the business applications, as the top level in the component hierarchy is the business service. A business service is the way to group the different kinds of IT resources into a logical group, and this logical group acts together as one unit to provide the service. Business services can contain any number of the lower-level resources. The result of step 2 is a grouped list by business service of all directly and indirectly related components.

IFCFIA Step 3: Creating the CFIA Grid:
A CFIA grid is created showing the auto-discovered components on one axis and on the other axis the IT business services which have a dependency on the components. In the matrix we can list all data relevant for the loosely coupling assessment including the business RTO/RPO targets.
The grid is complemented with the calculated or assessed coupling degrees for loosely and tightly coupling. The tightly coupling index is defined as inter-modular coupling metric, which calculate the coupling between each pair of directly related components. For loosely coupling an intrinsic coupling metric is chosen as this refers to the individual components' resilience capabilities. The CFIA will also show the assessed level of certainty next to the loosely and tightly coupling index.

IFCFIA Step 4: Defining the direct impact as IFS:
As next step for the two independent loosely- and tightly coupling indexes a combined representation into an integrated Intuitionistic Fuzzy Set (IFS) is created. This requires the two coupling indexes A and B to be normalized and combined by IFS operations (we choose the fuzzy operation A@¬B). The result of step 4 is a combinatorial IFS describing the coupling dependency between two components (inter-modular). This will be called the intuitionistic fuzzy probabilistic direct impact between two components. The determined direct coupling index can be added to the CFIA grid as additional column.

IFCFIA – Seven Step Approach

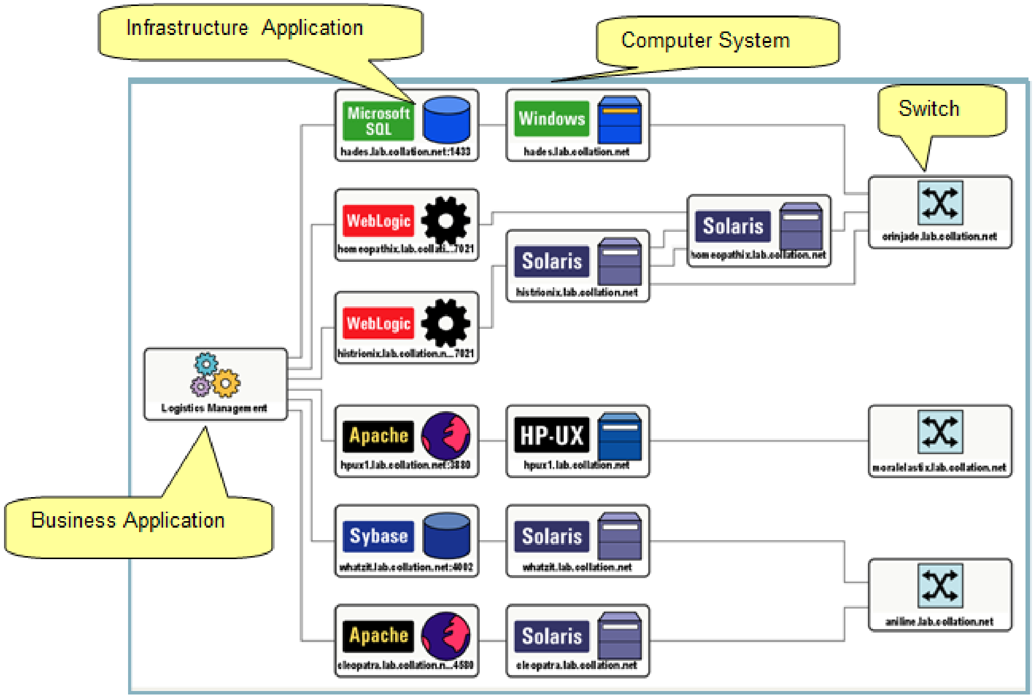
IFCFIA Step 5: Calculating the indirect couplings as IFS:
After defining the direct couplings as inter-modular IFS, the indirect coupling between components or services can be calculated considering the degrees for direct coupling. Here we can involve different probabilistic variants of the logical operations in calculation of the indirect impacts. This allows modelling the way the incident impact is transferred throughout the complex system. Depending on the operation logic that will be applied on the IFS, the indirect impacts may be greater or smaller. Therefore several basic types of impact analysis are introduced: worst case (pessimistic), best case (optimistic) and moderate impact analyses. The result of step 5 is the coupling index of each component to the front-end business service represented as indirect coupling IFS.

IFCFIA Step 6 (optional): Extending the Business View
The IFCFIA may be optional extended with additional logical dependencies and business impact information. For operation of IT systems we need to know also about dependencies to e.g. IT users and roles, organizational elements, supporting processes or maintenance services. This can be expressed with a coupling relationship like – is coupled to: a procedure, a Service Level Agreement (SLA) or even technical- or user documentation. Also business impact information can be added to the business service like hourly cost of failure or impacted users. Thus when a component is unavailable, the number of users impacted is understood and an impact calculation based on the cost of unavailability can be performed.

IFCFIA Step 7 (optional): Applying Intuitionistic Fuzzy Reasoning
As last step the IFCFIA allows the application for two-sided (intuitionistic) fuzzy reasoning by combining both aspects including the vagueness of the fact into inference rules and logics. Using two-sided fuzzy logic, the complex system behaviour can be closely analysed by considering both contrary coupling aspects simultaneously. Two-sided fuzzy if-then rules can consider different interpretations of fuzzy implications, by applying the best suited IFR bi-polar operations and interpretations.

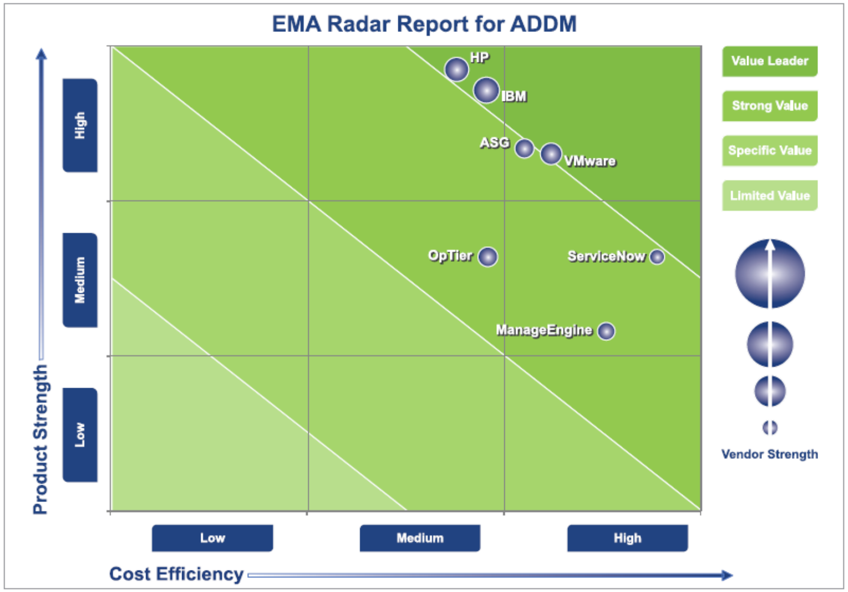
IFCFIA provides an outstanding view on a complex system relations and dependencies by listing it's components with direct and indirect couplings to the impacted business functions and can now be leveraged for several business-critical scenarios.

IFCFIA Step 1: CMDB auto-discovery



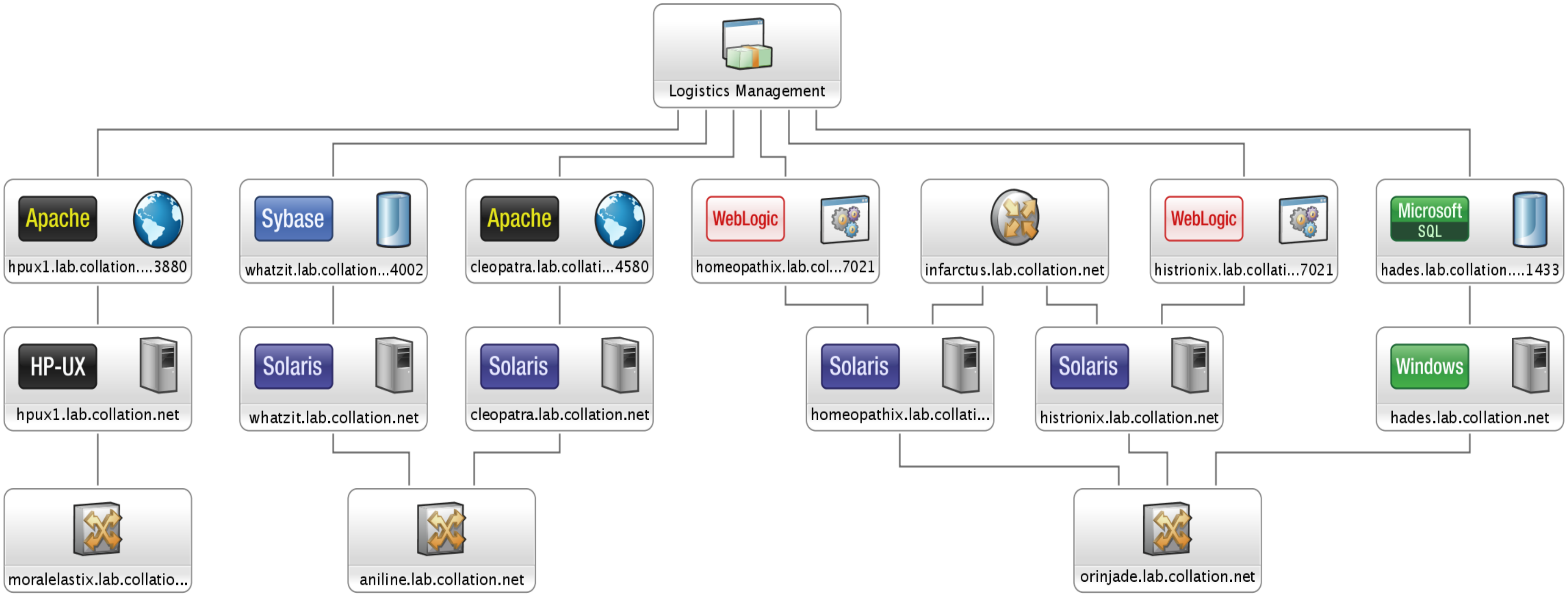
EMA Radar Map for ADDM
[Craig, EMA ADDM Radar Dec 10]

EMA Radar Map for Application Discovery and Dependency Mapping



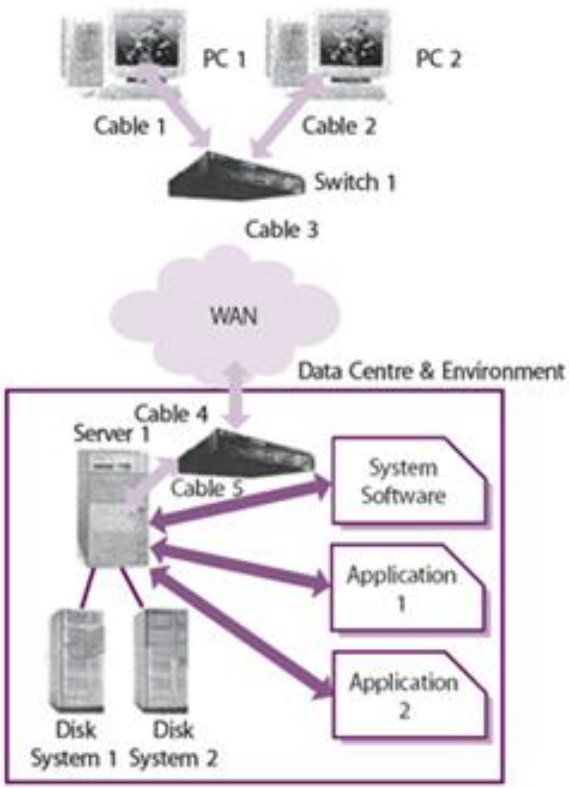
The automated discovery engine of a CMDB to retrieve attributes of Configuration Items (CIs), and relationships with other CIs is handled by tools called Application Dependency Discovery Manager.

IFCFIA Step 2: Defining the Business Service's Dependency Tree



The in-scope discovered component items are grouped to form the business applications, as the top level in the component hierarchy is the business service. A business service is the way to group the different kinds of IT resources into a logical group, and this logical group acts together as one unit to provide the service. Business services can contain any number of the lower-level resources.

IFCFIA Step 3: Creating the CFIA Grid (ITIL v3 Best Practices) Component Failure Impact Analysis (CFIA)



Configuration Item:	Appl.1	Appl.2
PC #1	B	B
PC #2		B
Cable #1	B	B
Cable #2		B
Outlet #1	X	X
Outlet #2		X
Ethernet segment	X	X
Router	X	X
Wan Link	X	X
Router	X	X
Segment	X	X
NIC	A	A
Server	B	B
System software	B	B
Application	B	B
Database	X	X

X = Fault means service is unavailable
A = Failsafe configuration
B = Failsafe, with changeover time
" " = No impact

Example of a basic CFIA Matrix

A CFIA grid is created showing the auto-discovered components on one axis and on the other axis the IT business services which have a dependency on the components. In the matrix we can list all data relevant for the loosely coupling assessment including the business RTO/RPO targets.

Loosely and Tightly Coupling Measurements in CFIA Grid

two types of a logical relationship which expresses the level of interdependency between components

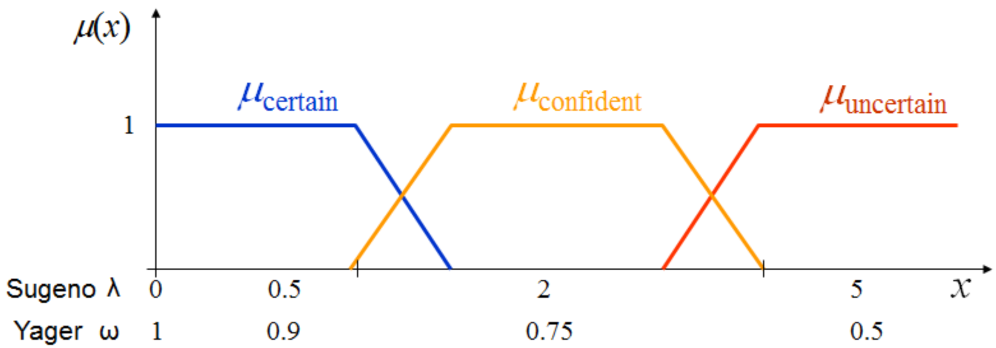
Is tightly coupled - and - is loosely coupled

Example extended CFIA Grid with coupling

Loosely Coupling is therefore defined as a measurement on the level the dependent component can complete the delivery of its service even the coupled component fails or is degraded in operation.

Component	Discovered Node Id	Parent Node Id's	% Availibility QPI	Mean Time to Repair (MTTR) in hours	Mean Time Between Failures (MTBF) in hours	Hot/Warm Failover: Failover Method	Hot/Warm Failover: Procedures (Y/N)	Hot/Warm Failover: Tested (Y/N)	Cold Recovery: Recovery Method	Cold Recovery: Procedures (Y/N)	Cold Recovery: Tested (Y/N)	Recovery Procedure: Integrated Recovery	Recovery Procedure: Partly Integrated	Single Point of Failure (SPOF)	Failure Mode and Effect	Loosely Coupling Index (resilience)	Certainty LC: Very High, High, Medium, Low, Very Low	Tightly Coupling Index (direct parent)	Certainty TC: Very High, High, Medium, Low, Very Low	RTO 2 hours RPO 4 hours / # Users / coupling to Bus. Service 1	RTO 12 hours RPO 12 hours / # Users / coupling to Bus. Service 2
Switch A	S-01	BusServ	99.99	24	10.000	N	N	N	Y	Y	N	N	Y	Y	Outage	0.75	VH	0.30	H	X	
Firewall A	F-01	S-01	99.85	24	10.000	Y	Y	N	N	N	N	Y	N	N	Outage	0.88	VH	0.90	H	X	
Firewall B	F-02	S-01	99.85	24	10.000	Y	Y	N	N	N	N	Y	N	N	Outage	0.88	VH	0.90	H	X	
Load-Balancer A1	L-01	F-01,F02	99.50	24	10.000	Y	Y	N	N	N	N	Y	N	N	Outage	0.88	M	0.78	M	X	
Load-Balancer A1	L-01	F-01,F02	99.50	24	10.000	Y	Y	N	N	N	N	Y	N	N	Slow Response	0.55	M	0.67	M	X	
Load-Balancer A1	L-01	F-01,F02	99.50	24	10.000	Y	Y	N	N	N	N	Y	N	N	Limited Function	0.60	H	0.72	H	X	
Load-Balancer A2	L-02	F-01,F02	99.50	24	10.000	Y	Y	N	N	N	N	Y	N	N	Outage	0.88	H	0.88	H	X	
HTTP Server A	HS-01	L-01,L02	99.10	48	5.000	Y	Y	N	N	N	N	Y	N	N	Slow Response	0.88	H	0.88	H	X	X
HTTP Server B	HS-02	L-01,L02	99.10	48	5.000	Y	Y	N	N	N	N	Y	N	N	Slow Response	0.88	H	0.67	H	X	
Firewall C	F-03	HS-01,HS-02	99.85	24	10.000	Y	Y	N	N	N	N	Y	N	N	Outage	0.75	VH	0.45	H	X	
Firewall D	F-04	HS-01,HS-02	99.85	24	10.000	Y	Y	N	N	N	N	Y	N	N	Outage	0.75	VH	0.75	H	X	
Application Server A	AS-01	F-03,F04	99.20	12	2.000	Y	Y	N	N	N	N	Y	N	N	Slow Response	0.82	M	0.82	M	X	X
Application Server B	AS-02	F-03,F04	99.20	12	2.000	Y	Y	N	N	N	N	Y	N	N	Slow Response	0.82	M	0.45	M	X	
Content Server C	CS-03	AS-01,AS-02	99.10	48	5.000	N	N	N	Y	Y	Y	N	N	Y	Slow Response	0.88	H	0.30	H	X	
Directory Server	DIS-01	AS-01,AS-02	99.30	12	2.000	Y	Y	N	N	N	N	Y	N	Y	Outage	0.35	M	0.75	M	X	
Ext.Data Feed Server	ES-01	AS-01,AS-02	88.70	48	5.000	N	N	N	Y	Y	Y	N	N	Y	Limited Function	0.48	M	0.67	VL		X
Monitoring Server	MS-01	HS-01,HS-02 AS-01,AS-02	99.30	48	5.000	N	N	N	Y	Y	Y	N	N	Y	none (no monitoring)	0.65	M	0.20	M	X	
Database Server A	DS-01	AS-01,AS-02	99.50	12	10.000	Y	Y	N	N	N	N	Y	N	N	Limited Function	0.57	L	0.67	L	X	X
Database Server B	DS-02	AS-01,AS-02	99.50	12	10.000	Y	Y	N	N	N	N	Y	N	N	Limited Function	0.57	L	0.30	L	X	
SAN	SAN-01	DS-01,DS-02	99.85	24	50.000	N	N	N	N	N	N	N	N	Y	Outage	0.69	H	0.89	H	X	X

IFCFIA Step 4: Creating the direct coupling index as single IFS



4a) Create two independent IFS for loosely and tightly coupling

- Map Certainty to complement parameter for Sugeno or Yager
- Calculate complementary Membership Degree (= non-membership degree)

4b) Combine both independent IFS to integrated Result IFS

IFS operation [Atanassov 08] A@¬B

$$\mu_{combined}(x) = \frac{\mu_A(x) + \nu_B(x)}{2} \quad \text{and}$$

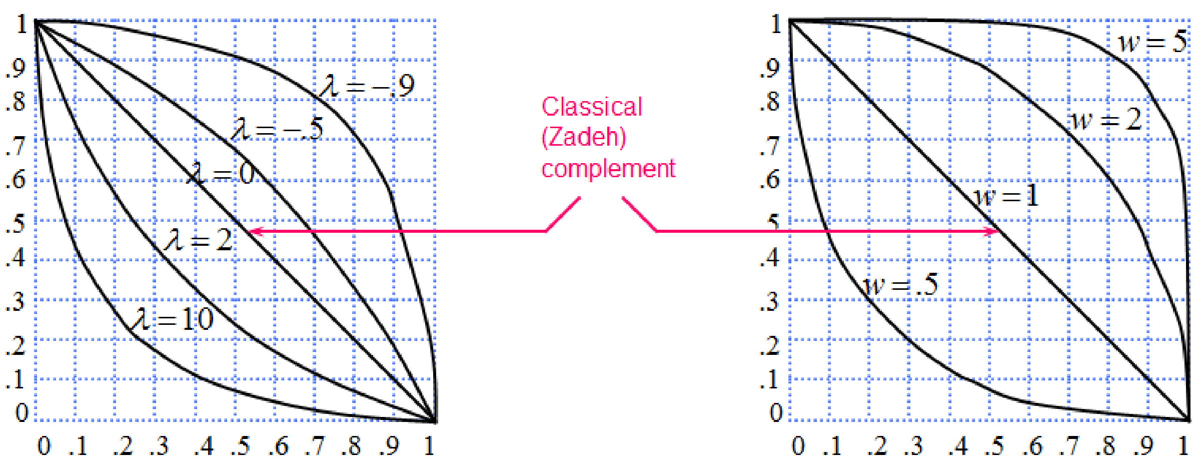
$$\nu_{combined}(x) = \frac{\nu_A(x) + \mu_B(x)}{2}$$

Sugeno's complement:

$$c_\lambda(a) = \frac{1-a}{1+\lambda a} \qquad \lambda \in (-1, \infty)$$

Yager's complement :

$$c_w(a) = \left(1 - a^w\right)^{\frac{1}{w}} \qquad w \in (0, \infty)$$



The result of step 4 is the fuzzy intuitionistic direct coupling impact between two components. The direct coupling IFS can be now added to the CFIA grid.

Fault Tree Analysis concept of Kolev/Ivanov

Thirteenth Int. Conf. on IFSs, Sofia, 9-10 May 2009
NIFS Vol. 15 (2009) 2, 10-17

Fault Tree Analysis in an Intuitionistic Fuzzy Configuration Management Database

Boyan Kolev[1], Ivaylo Ivanov[2]

[1] – CLBME – Bulgarian Academy of Sciences, Bl. 105, Sofia-1113, Bulgaria
E-mail: bik@clbme.bas.bg

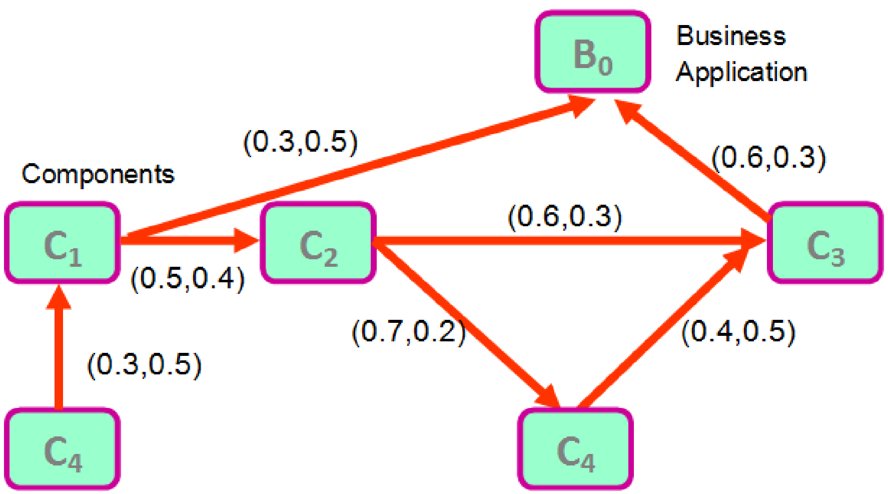
[2] – SoftConsultGroup Ltd – Dedeagach Str, Bl. 60A, c-x Strelbishte, Sofia-1408, Bulgaria
E-mail: ivaylo.ivanov@softconsultgroup.com

IFCFIA Step 5: Calculation of the indirect couplings

Depending on which combination of IFS operations will be used, the indirect impacts may be greater or smaller. Four types of impact analysis are introduced: worst case (pessimistic), best case (optimistic), moderate and classical fuzzy analyses based on the Fault Tree Analysis concept of Kolev/Ivanov in 2009:

Worst case impact analysis $V(p \wedge q) = \langle \min(\mu(p), \mu(q)), \max(\nu(p), \nu(q)) \rangle$ $V(a \vee b) = \langle \mu(a) + \mu(b) - \mu(a).\mu(b), \nu(a).\nu(b) \rangle$	**Best case impact analysis** $V(p \wedge q) = \langle \mu(p).\mu(q), \nu(p) + \nu(q) - \nu(p).\nu(q) \rangle$ $V(a \vee b) = \langle \max(\mu(a), \mu(b)), \min(\nu(a), \nu(b)) \rangle$
Moderate impact analysis $V(p \wedge q) = \langle \mu(p).\mu(q), \nu(p) + \nu(q) - \nu(p).\nu(q) \rangle$ $V(a \vee b) = \langle \mu(a) + \mu(b) - \mu(a).\mu(b), \nu(a).\nu(b) \rangle$	**Classical fuzzy impact analysis** $V(p \wedge q) = \langle \min(\mu(p), \mu(q)), \max(\nu(p), \nu(q)) \rangle$ $V(a \vee b) = \langle \max(\mu(a), \mu(b)), \min(\nu(a), \nu(b)) \rangle$

As an example of the calculation with the Forward Coupling Calculation (FCC) method (used for Impact Analysis) of $indcpl(C_2,B_0)$ depicted in the graph above shows the indirect coupling dependency of the Business Application B_0 on the on the Component C_2 :



$indcpl(C_2,B_0) = (dircpl(C_2,C_3) \vee (dircpl(C_2,C_4) \wedge dircpl(C_4,C_3))) \wedge dircpl(C_3,B_0)$

Applying a classical indirect coupling operation $indcpl_{classic}(C_2,B_0)$ = (0.60,0.30) is the result set. When using a moderate impact assessment $indcpl_{moderate}(C_2,B_0)$ = (0.43,0.43), with a worst case impact assessment $indcpl_{worst}(C_2,B_0)$ = (0.60,0.30) and for a best case impact assessment $indcpl_{best}(C_2,B_0)$ = (0.36,0.51).

Intuitionistic Fuzzy Component Failure Impact Analysis (IFCFIA) Matrix

IFCFIA Grid with indirect couplings					RTO 2 hours RPO 4 hours		RTO 12 hours RPO 12 hours		
					Bus. Service 1 # Users 700		Bus. Service 2 # Users 300		
Component	Discovered Node Id	Parent Node Id's	Failure Mode and Effect	Direct Impact (IFS) on parent	FCC coupling to Business Service 1	RCC coupling from Business Service 1	FCC coupling to Business Service 2	RCC coupling from Business Service 2	total End Users impacted
Switch A	S-01	BusServ	Outage	(0.4,0.4)	(0.4,0.4)	(0.4,0.4)			700
Firewall A	F-01	S-01	Outage	(0.6,0.3)	(0.3,0.5)	(0.4,0.5)			700
Firewall B	F-02	S-01	Outage	(0.5,0.4)	(0.3,0.5)	(0.4,0.5)			700
Load-Balancer A1	L-01	F-01,F02	Outage	(0.5,0.5)	(0.4,0.4)	(0.6,0.3)			700
Load-Balancer A1	L-01	F-01,F02	Slow Response	(0.4,0.5)	(0.6,0.3)	(0.8,0.1)			700
Load-Balancer A1	L-01	F-01,F02	Limited Function	(0.4,0.5)	(0.3,0.5)	(0.2,0.6)			700
Load-Balancer A2	L-02	F-01,F02	Outage	(0.3,0.6)	(0.3,0.5)	(0.2,0.6)			700
HTTP Server A	HS-01	L-01,L02	Slow Response	(0.8,0.1)	(0.6,0.3)	(0.7,0.3)	(0.6,0.3)	(0.7,0.3)	1000
HTTP Server B	HS-02	L-01,L02	Slow Response	(0.5,0.4)	(0.7,0.3)	(0.8,0.1)			700
Firewall C	F-03	HS-01,HS-02	Outage	(0.5,0.4)	(0.6,0.3)	(0.5,0.5)			700
Firewall D	F-04	HS-01,HS-02	Outage	(0.2,0.6)	(0.3,0.5)	(0.2,0.6)			700
Application Server A	AS-01	F-03,F04	Slow Response	(0.8,0.1)	(0.6,0.3)	(0.7,0.3)	(0.7,0.3)	(0.6,0.3)	1000
Application Server B	AS-02	F-03,F04	Slow Response	(0.8,0.1)	(0.7,0.3)	(0.8,0.1)			700
Content Server C	CS-03	AS-01,AS-02	Slow Response	(0.5,0.4)	(0.6,0.3)	(0.3,0.5)			700
Directory Server	DIS-01	AS-01,AS-02	Outage	(0.2,0.6)	(0.3,0.5)	(0.4,0.5)			700
Ext.Data Feed Server	ES-01	AS-01,AS-02	Limited Function	(0.5,0.4)			(0.6,0.3)	(0.7,0.3)	300
Monitoring Server	MS-01	HS-01,HS-02 AS-01,AS-02	none (no monitoring)	(0.5,0.4)	(0.6,0.3)	(0.7,0.3)			700
Database Server A	DS-01	AS-01,AS-02	Limited Function	(0.8,0.1)	(0.7,0.3)	(0.8,0.1)	(0.8,0.1)	(0.7,0.3)	1000
Database Server B	DS-02	AS-01,AS-02	Limited Function	(0.5,0.4)	(0.6,0.3)	(0.7,0.3)			700
SAN	SAN-01	DS-01,DS-02	Outage	(0.4,0.5)			(0.7,0.3)	(0.8,0.1)	300

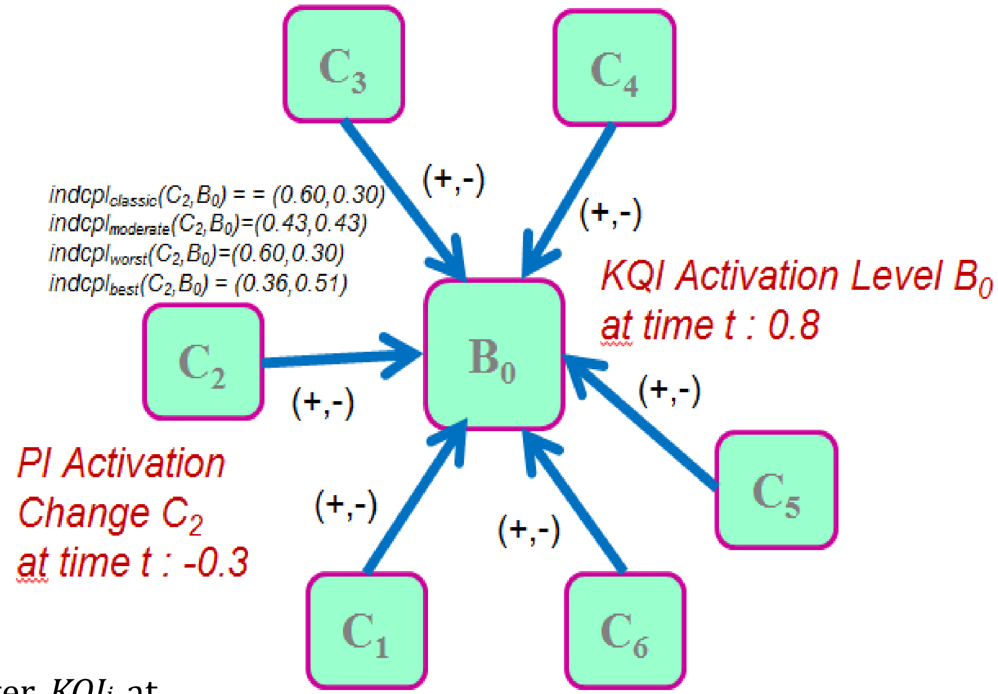
Impact Analysis
Having built the grid, components that have a lhigh coupling and arge number of Xs are critical and can result in high impact should the component fail

Fault Tree Analysis
The IFCFIA analysis procedure takes into account direct and indirect impacts of other components over the failed components. The result of the analysis is an intuitionistic fuzzy distribution of components giving an ordered set of possible root causes. Having the IFCFIA we simply need to sort for the highest level of IFS coupling to get an order for possible root causes.

IFCFIA Step 5b: (optional) : From bi-modal to gradual failure situations Applying the basic mathematical model of Fuzzy Cognitive Maps

For the calculated indirect couplings as one-level dependency graph apply now the standard mathematical model of the FCM approach to compute the value of each quality parameter that influenced by the values of the coupled quality indicator with the appropriate weights and by its previous value. So the value Ai for each quality indicator KQIi can be calculated by the following rule:

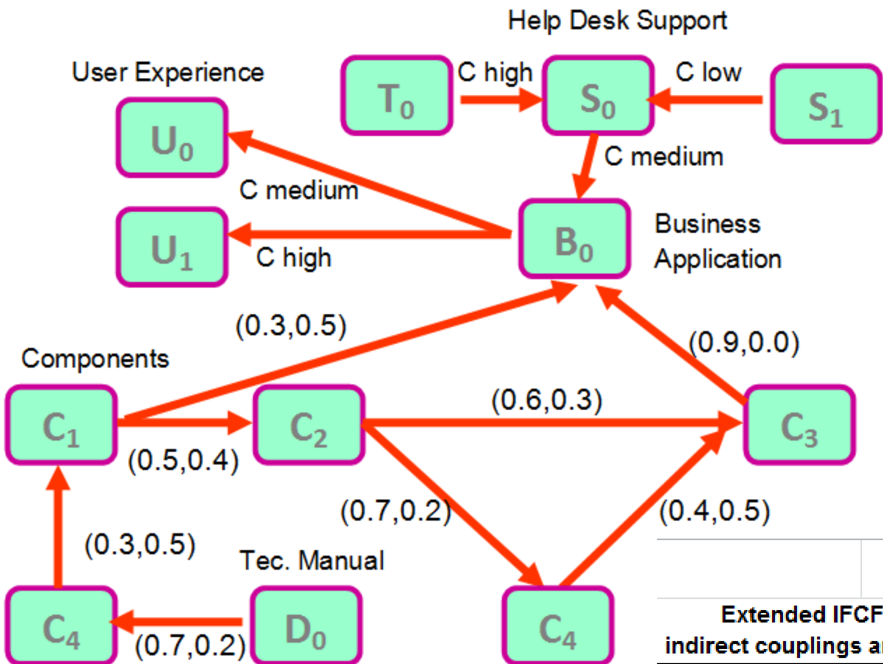
$$A_i = f\left(\sum_{\substack{j=1 \\ j \neq i}}^{n} A_j W_{ji}\right) + A_i^{old}$$



where A_i is the activation level of quality parameter KQI_i at time $t+1$, A_j is the activation level of quality parameter KQI_j at time t, $A_{i\,old}$ is the activation level of quality parameter KQI_i at time t, and W_{ji} is the weight of the dependence coupling between KQI_j and KQI_i , and f is a threshold function.

The weights of the dependencies between the KQI_i and KQI_j could be positive ($W_{ji}>0$) which means that an increase in the value of KQI_i leads to the increase of the value of KQI_j, and a decrease in the value of KQI_i leads to the decrease of the value of KQI_j. Or there is negative causality ($W_{ji}<0$) which means that an increase in the value of KQI_i leads to the decrease of the value of KQI_j and vice versa.

IFCFIA Step 6: (optional) Extending the Business View



IT Enabled Services (ITeS) model which typically include a large human element. For operation of IT systems we need to know also about dependencies to e.g. IT users and roles, IT staff, IT organizational elements, business units and supporting processes and functions e.g. helpdesk or maintenance services. This can be expressed also with a logical association relationship like – is coupled to: a procedure, a Service Level Agreement or a manual, a user documentation or a support function like help desk.

Adding the Costs of Failure

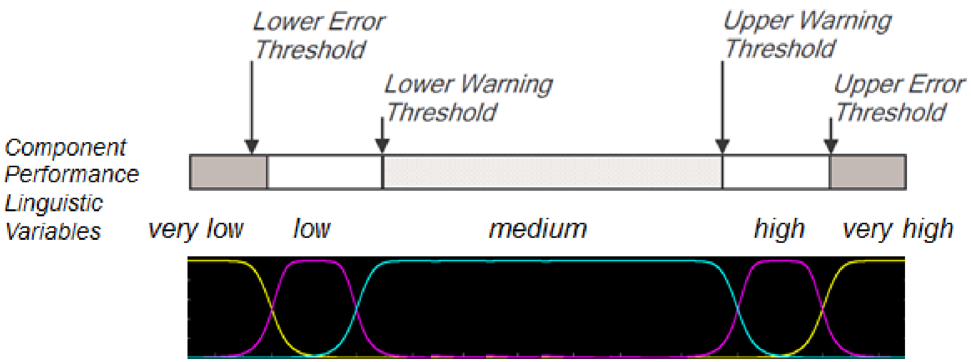
$$C_{CI} = \sum_{i=1..n}^{n} \mu_A(x)_i * C_i$$

CCI denotes the hourly cost of a of the component item, *μA(x)i* is the degree of membership of tightly coupling to the business application *i* and *Ci* denotes the hourly cost of a failure of the business application *i*. For instance the hourly cost of failure for the node HS-01 Http Server as it is *CHttpServer = 0.6 * 10.000 + 0.5 * 3,000 = 7500*

Extended IFCFIA Grid with indirect couplings and cost of failure

Component	Discovered Node Id	Parent Node Id's	Failure Mode and Effect	Direct Impact (IFS) on parent	Bus. Service 1 # Users 700 (cost of failure 10.000 per hour; RTO 2 hours RPO 4 hours)		Bus. Service 2 # Users 300 (cost of failure 3.000 per hour; RTO 12 hours RPO 12 hours)		total End Users impacted	total cost of failure per hour
					FCC coupling to Business Service 1	RCC coupling from Business Service 1	FCC coupling to Business Service 2	RCC coupling from Business Service 2		
Switch A	S-01	BusServ	Outage	(0.4,0.4)	(0.4,0.4)	(0.4,0.4)			700	4000
Firewall A	F-01	S-01	Outage	(0.6,0.3)	(0.3,0.5)	(0.4,0.5)			700	3000
Load-Balancer A1	L-01	F-01,F02	Outage	(0.5,0.5)	(0.4,0.4)	(0.6,0.3)			700	4000
Load-Balancer A1	L-01	F-01,F02	Limited Function	(0.4,0.5)	(0.3,0.5)	(0.2,0.6)			700	4000
HTTP Server A	HS-01	L-01,L02	Slow Response	(0.8,0.1)	(0.6,0.3)	(0.7,0.3)	(0.5,0.3)	(0.7,0.3)	1000	7500
How-to Manual	Sup1	HS-01	Quality Issue	(0.2,0.6)	(0.3,0.5)	(0.2,0.6)			700	3000
Technical Support	Org2	HS-01	Slow Repair	(0.8,0.1)	(0.8,0.1)	(0.8,0.1)			700	8000
Helpdesk	Org1	BusServ	Quality Issue	(0.6,0.3)	(0.6,0.3)	(0.7,0.3)	(0.6,0.3)	(0.7,0.3)	1000	7800

IFCFIA Step 7: (optional) Intuitionistic Fuzzy Reasoning



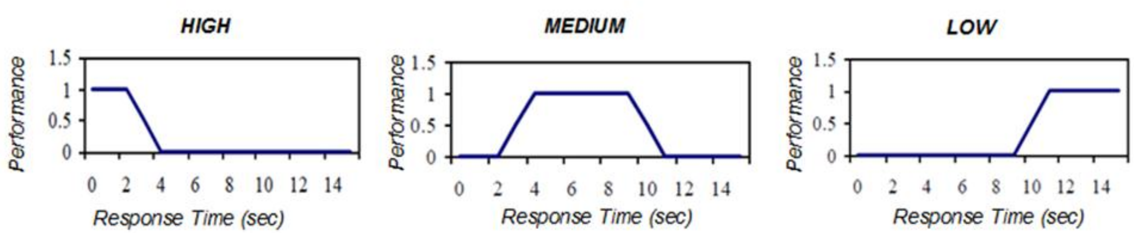
The IFCFIA Grid shows the coupling relation for each low-level component to the related business applications and services. The tightly and loosely coupled values are an aggregation level over all indirect couplings and dependencies.

Now general rules can be formulated, for instance for QoS sensitive to the tightly coupled aspect (most ordinary measurements, like response time) :

1. *If ("Component Service" is tightly coupled > 0.7) to "Business Service" and "Component Service" performance is LOW) then "Business Service" performance is LOW.*
2. *If ("Component Service" is tightly coupled > 0.7) to "Business Service" and "Component Service" performance is MEDIUM) then "Business Service" performance is MEDIUM.*
3. *If ("Business Service" is tightly coupled > 0.5 to "User Experience" and "Business Service" performance is LOW) then "User Experience is low"*

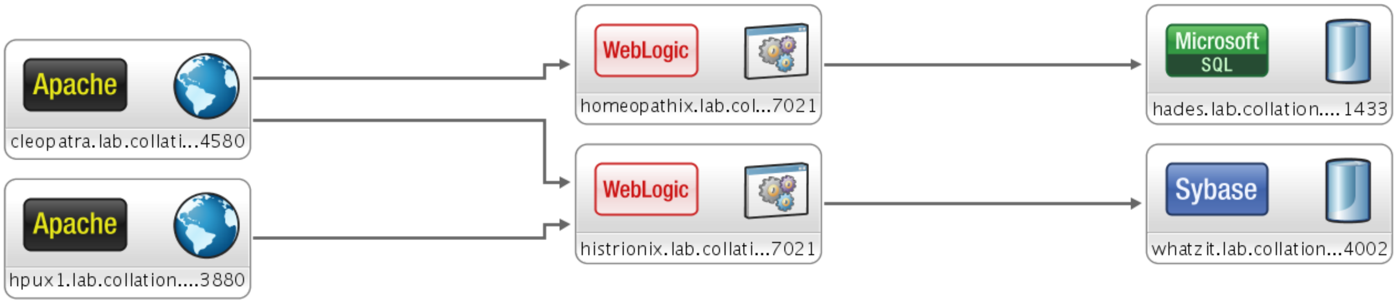
More sophisticated roles can use both aspects for tightly and loosely coupling :

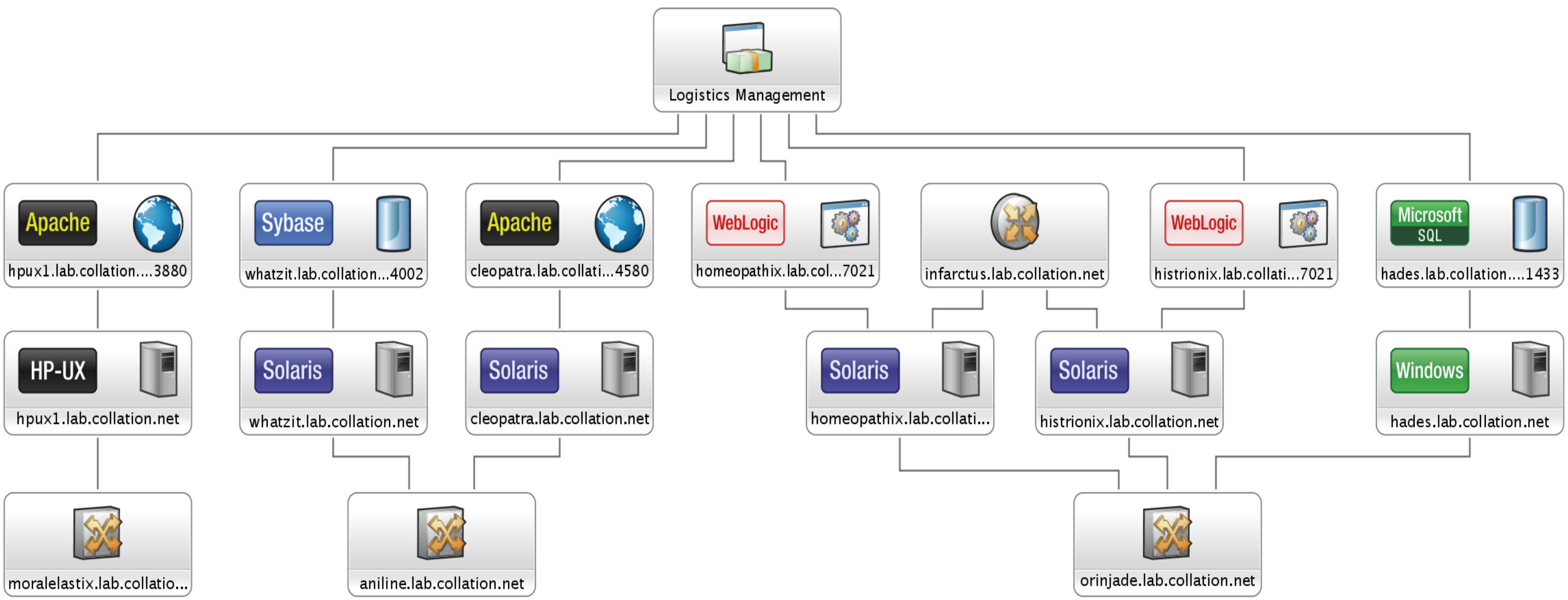
1. *If ("Component Service" is tightly coupled > 0.5 and loosely coupled < 0.4) to "Business Service" and "Component Service" performance is LOW and "Component Service" reliability is LOW) then "Business Service" performance is VERY LOW*



1. Background and Problem Statement
2. Interdependencies & Couplings
3. Intuitionistic Fuzzy Sets
4. IFCFIA Solution Approach
5. IFCFIA Use Cases

TADDM auto-discovery of Logistics Management





Logistics Management Dependency Tree

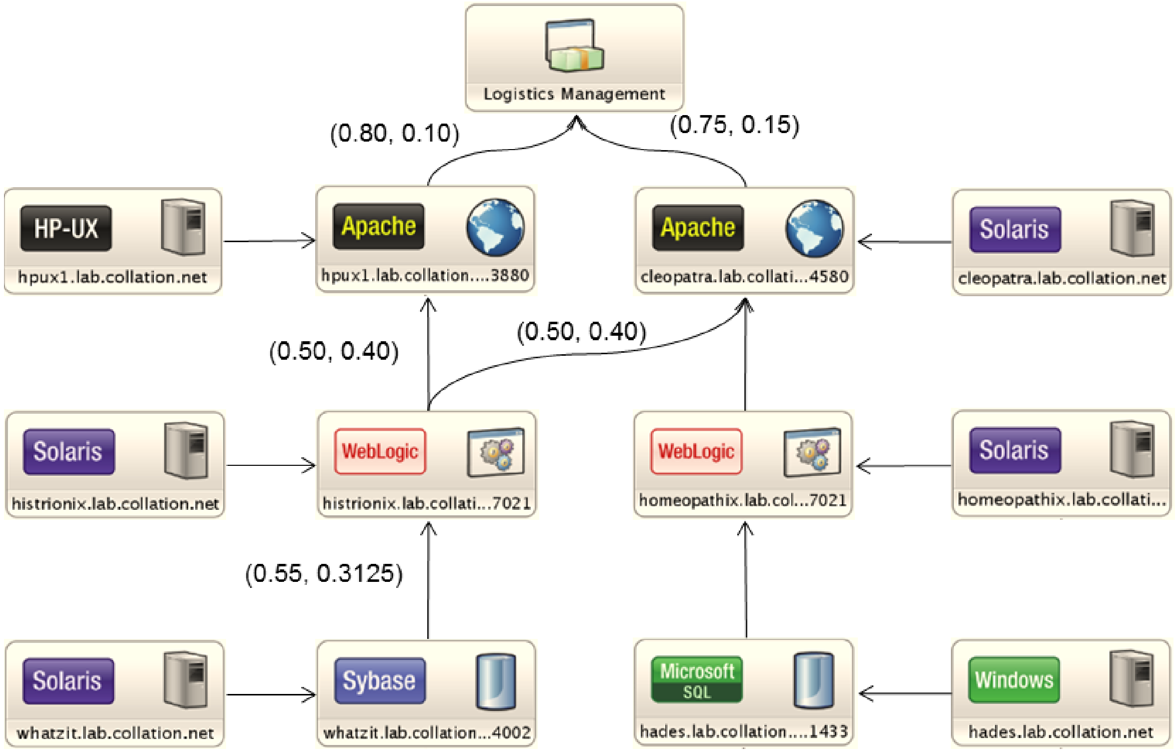
Hierarchy Level	Discovered Component Configuration Item (CI)	Discovered Component Id	Dependency Type	Parent Component Id's	Parent Component Type
L2	Web Server	hpux1.lab.collation.net:3880	composition	Logistics Management	Business Application
L3	HP UX Computer System	hpux1.lab.collation.net	service	hpux1.lab.collation.net:3880	Software Component
L3	HP UX Computer System	hpux1.lab.collation.net	service	hpux1.lab.collation.net:3880	Software Component
L4	Cisco	moralelastic.lab.collation.net	service	hpux1.lab.collation.net	Computer System
L4	ethernet-scmacd	ethernet-scmacd (6)	service	hpux1.lab.collation.net	Computer System
L3	Java Server	caesar.lab.collation.net:2809	transactional	hpux1.lab.collation.net:3880	Apache AppServer
L4	Computer System	panacea.lab.collation.net	service	caesar.lab.collation.net:2809	Software Component
L3	WebLogic Server	histronixlab.collation.net:7021	transactional	hpux1.lab.collation.net:3880 cleopatra.lab.collation.net:4580	Apache AppServer
L4	Sun Sparc Computer System	histronixlab.collation.net	service	histronixlab.collation.net:7021	Software Component
L5	Network Device	dmfe1	service	histrionixlab.collation.net	Computer System
L4	Sybase Server Enterprise	whatzitlab.collation.net:4002	transactional	histrionixlab.collation.net:7021	WebLogic Server
L5	Sun Sparc Computer System	whatzitlab.collation.net	service	whatzit.lab.collation.net:4002	Software Component
L2	Web Server	cleopatra.lab.collation.net:4580	composition	Logistics Management	Business Application
L4	Sun Sparc Computer System	cleopatra.lab.collation.net	service	cleopatra.lab.collation.net:4580	Software Component
L3	WebLogic Server	homeopathixlab.collation.net:7021	transactional	cleopatra.lab.collation.net:4580	Apache AppServer
L4	Sun Sparc Computer System	homeopathixlab.collation.net	service	homeopathixlab.collation.net:7021	Software Component
L5	Network Device	dmfe2	service	homeopathixlab.collation.net	Computer System
L3	WebLogic Server	histrionix.lab.collation.net:7021	transactional	hpux1.lab.collation.net:3880 cleopatra.lab.collation.net:4580	Apache AppServer
L4	Sun Sparc Computer System	histronixlab.collation.net	service	histronixlab.collation.net:7021	Software Component
L4	Microsoft SQL Server	hades.lab.collation.net:1433	transactional	homeopathixlab.collation.net:7021	WebLogic Server
L5	Windows Computer System	hades.lab.collation.net	service	hades.lab.collation.net:1433	Software Component
L6	Intel PRO/1000 MT	Intel PRO/1000 MT Network 2	service	hades.lab.collation.net	Computer System
L4	Sybase Adaptive Server IQ	brutus.lab.collation.net:2638	transactional	homeopathixlab.collation.net:7021	WebLogic Server
L5	Sun Sparc Computer System	brutus.lab.collation.net	service	brutus.lab.collation.net:2638	Software Component
L4 L5	DNS/NIS service	majestix.eng.collation.net:53	service	histrionixlab.collation.net:7021 brutus.lab.collation.net:2638 homeopathixlab.collation.net:7021 whatzit.lab.collation.net:4002	Web Logic Server Sybase Server
L5,6	Computer System	majestix.eng.collation.net	service	majestix.eng.collation.net:53	Software Component
L3 L5	Cisco Router	aniline.lab.collation.net	service	cleopatra.lab.collation.net whatzit.lab.collation.net	Computer System

IFCFIA – Loosely and Tightly Coupling Index

Discovered Component Configuration Item (CI)	Discovered Component Id	Failure Mode and Effect	% Availibility QPI	Mean Time to Repair in hours	Mean Time Between Failures (MTBF) in hours	Hot/Warm Failover: Failover	Hot/Warm Failover: Procedures	Hot/Warm Failover: Tested (Y/N)	Cold Recovery: Recovery Method	Cold Recovery: Procedures (Y/N)	Cold Recovery: Tested (Y/N)	Recovery Proc.: Integrated	Recovery Proc.: Partly Integrated	Single Point of Failure	Loosely Coupling Index (resilience)	Certainty LC: Very High, High, Medium, Low, VL
Web Server	hpux1.lab.collation.net:3880	Outage	99.99	24	10.000	N	N	N	Y	Y	N	N	Y	Y	0.75	VH
HP UX Computer System	hpux1.lab.collation.net	Outage	99.50	24	10.000	Y	Y	N	N	N	N	Y	N	N	0.88	H
HP UX Computer System	hpux1.lab.collation.net	Slow Response	99.50	24	10.000	Y	Y	N	N	N	N	Y	N	N	0.88	H
Cisco	moralelastic.lab.collation.net	Limited Function	99.20	12	2.000	Y	Y	N	N	N	N	Y	N	N	0.82	M
ethernet-scmacd	ethernet-scmacd (6)	Limited Function	99.30	48	5.000	N	N	N	Y	Y	Y	N	N	Y	0.65	M
Java Server	caesar.lab.collation.net:2809	Outage	99.85	24	50.000	N	N	N	N	N	N	N	N	Y	0.69	H
Computer System	panacea.lab.collation.net	Slow Response	99.20	12	2.000	Y	Y	N	N	N	N	Y	N	N	0.82	M
WebLogic Server	histronix.lab.collation.net:7021	Outage	99.85	24	10.000	Y	Y	N	N	N	N	Y	N	N	0.75	VH
Sun Sparc Computer System	histronix.lab.collation.net	Outage	99.20	12	2.000	Y	Y	N	N	N	N	Y	N	N	0.82	M
Network Device	dmfe1	Limited Function	99.50	12	10.000	Y	Y	N	N	N	N	Y	N	N	0.57	L
Sybase Server Enterprise	whatzit.lab.collation.net:4002	Outage	99.85	24	10.000	Y	Y	N	N	N	N	Y	N	N	0.88	VH

Discovered Component Configuration Item (CI)	Discovered Component Id	Dependency Type	Parent Component Id's	Failure Mode and Effect	Tightly Coupling Index (direct parent)	Certainty TC: Very High, High, Medium, Low, VL	Direct Impact (IFS) on parent
Web Server	hpux1.lab.collation.net:3880	composition	Logistics Management	Outage	0.30	H	(0.4,0.4)
HP UX Computer System	hpux1.lab.collation.net	service	hpux1.lab.collation.net:3880	Outage	0.88	H	(0.3,0.6)
HP UX Computer System	hpux1.lab.collation.net	service	hpux1.lab.collation.net:3880	Slow Response	0.88	H	(0.3,0.6)
Cisco	moralelastic.lab.collation.net	service	hpux1.lab.collation.net	Limited Function	0.45	M	(0.8,0.1)
ethernet-scmacd	ethernet-scmacd (6)	service	hpux1.lab.collation.net	Limited Function	0.20	M	(0.5,0.4)
Java Server	caesar.lab.collation.net:2809	transactional	hpux1.lab.collation.net:3880	Outage	0.89	H	(0.4,0.5)
Computer System	panacea.lab.collation.net	service	caesar.lab.collation.net:2809	Slow Response	0.45	M	(0.8,0.1)
WebLogic Server	histronix.lab.collation.net:7021	transactional	hpux1.lab.collation.net:3880 cleopatra.lab.collation.net:4580	Outage	0.75	H	(0.2,0.6)
Sun Sparc Computer System	histronix.lab.collation.net	service	histronix.lab.collation.net:7021	Outage	0.45	M	(0.8,0.1)
Network Device	dmfe1	service	histrionix.lab.collation.net	Limited Function	0.67	L	(0.8,0.1)
Sybase Server Enterprise	whatzit.lab.collation.net:4002	transactional	histrionix.lab.collation.net:7021	Outage	0.90	H	(0.5,0.4)
Sun Sparc Computer System	whatzit.lab.collation.net	service	whatzit.lab.collation.net:4002	Slow Response	0.67	H	(0.5,0.4)

Indirect Coupling Calculations



$indcpl(C_{whatzit:4002}, B_{LogisticsManagement}) =$
$indcpl(C_{whatzit:4002}, C_{hpux1:3880}) \wedge$
$dircpl(C_{hpux1:3880}, B_{LogisticsManagement}) \vee$
$indcpl(C_{whatzit:4002}, C_{cleopatra:4580}) \wedge$
$dircpl(C_{cleopatra:4580}, B_{LogisticsManagement})$
$= dircpl(C_{whatzit:4002}, C_{histronix:7021}) \wedge$
$((dircpl(C_{histronix:7021}, C_{hpux1:3880}) \wedge$
$dircpl(C_{hpux1:3880}, B_{LogisticsManagement})) \vee$
$(dircpl(C_{histronix:7021}, C_{cleopatra:4580}) \wedge$
$(C_{cleopatra:4580}, B_{LogisticsManagement})))$

Moderate impact assessment:
$indcpl_{moderate}(C_{whatzit:4002}, B_{LogisticsManagement}) =$
(0.3438,0.4675),

Worst case impact assessment:
$indcpl_{worst}(C_{whatzit:4002}, B_{LogisticsManagement}) =$
(0.5500,0.3125)

Best case impact assessment:
$indcpl_{best}(C_{whatzit:4002}, B_{LogisticsManagement}) =$
(0.2200,0.6288)

Classical impact assessment:
$indcpl_{classic}(C_{whatzit:4002}, B_{LogisticsManagement}) =$
(0.5000,0.4000)

Extended IFCFIA Grid with indirect couplings and cost of failure

							Level 0	Bill Payment Business Service					
							Level 1	Logistics Management		Billing Application			
								cost of failure 10.000 per hour		cost of failure 3.000 per hour			
								# Users 700 RTO 2 hours RPO 4 hours		# Users 300 RTO 12 hours RPO 12 hours			
Hierarchy Level	Discovered Component Configuration Item (CI)	Discovered Component Id	Dependency Type	Parent Component Id's	Parent Component Type	Failure Mode and Effect	Direct Impact (IFS) on parent	FCC moderate risk	RCC	FCC moderate risk	RCC	total End Users impacted	total cost of failure per hour
L2	Web Server	hpux1.lab.collation.net:3880	composition	Logistics Management	Business Application	Outage	(0.8,0.1)	(0.8,0.1)	(0.8,0.1)			700	8000
L3	HP UX Computer System	hpux1.lab.collation.net	service	hpux1.lab.collation.net:3880	Software Component	Outage	(0.3,0.6)	(0.3,0.5)	(0.2,0.6)			700	3000
L3	HP UX Computer System	hpux1.lab.collation.net	service	hpux1.lab.collation.net:3880	Software Component	Slow Response	(0.3,0.6)	(0.3,0.5)	(0.2,0.6)			700	3000
L4	Cisco	moralelastic.lab.collation.net	service	hpux1.lab.collation.net	Computer System	Limited Function	(0.8,0.1)	(0.7,0.3)	(0.8,0.1)			700	7000
L4	ethernet-scmacd	ethernet-scmacd (6)	service	hpux1.lab.collation.net	Computer System	Limited Function	(0.5,0.4)	(0.6,0.3)	(0.7,0.3)			700	6000
L3	Java Server	caesar.lab.collation.net:2809	transactional	hpux1.lab.collation.net:3880	Apache AppServer	Outage	(0.4,0.5)			(0.7,0.3)	(0.8,0.1)	300	2100
L4	Computer System	panacea.lab.collation.net	service	caesar.lab.collation.net:2809	Software Component	Slow Response	(0.8,0.1)	(0.7,0.3)	(0.8,0.1)			700	7000
L3	WebLogic Server	histronix.lab.collation.net:7021	transactional	hpux1.lab.collation.net:3880 cleopatra.lab.collation.net:4580	Apache AppServer	Outage	(0.2,0.6)	(0.3,0.5)	(0.2,0.6)			700	3000
L4	Sun Sparc Computer System	histronix.lab.collation.net	service	histronix.lab.collation.net:7021	Software Component	Outage	(0.8,0.1)	(0.7,0.3)	(0.8,0.1)			700	7000
L5	Network Device	dmfe1	service	histrionix.lab.collation.net	Computer System	Limited Function	(0.8,0.1)	(0.7,0.3)	(0.8,0.1)	(0.8,0.1)	(0.7,0.3)	1000	9400
L4	Sybase Server Enterprise	whatzit.lab.collation.net:4002	transactional	histrionix.lab.collation.net:7021	WebLogic Server	Outage	(0.5,0.4)	(0.3,0.5)	(0.4,0.5)			700	3000
L5	Sun Sparc Computer System	whatzit.lab.collation.net	service	whatzit.lab.collation.net:4002	Software Component	Slow Response	(0.5,0.4)	(0.7,0.3)	(0.8,0.1)			700	7000
L2	Web Server	cleopatra.lab.collation.net:4580	composition	Logistics Management	Business Application	Outage	(0.7,0.2)	(0.7,0.2)	(0.7,0.2)			700	3000
L4	Sun Sparc Computer System	cleopatra.lab.collation.net	service	cleopatra.lab.collation.net:4580	Software Component	Slow Response	(0.8,0.1)	(0.6,0.3)	(0.7,0.3)	(0.5,0.3)	(0.7,0.3)	1000	7500
L3	WebLogic Server	homeopathix.lab.collation:7021	transactional	cleopatra.lab.collation.net:4580	Apache AppServer	Outage	(0.5,0.5)	(0.4,0.4)	(0.6,0.3)			700	4000
L4	Sun Sparc Computer System	homeopathix.lab.collation.net	service	homeopathix.lab.collation.net:70	Software Component	Outage	(0.5,0.4)	(0.6,0.3)	(0.5,0.5)			700	6000
L5	Network Device	dmfe2	service	homeopathix.lab.collation.net	Computer System	Limited Function	(0.5,0.4)	(0.6,0.3)	(0.7,0.3)			700	6000
L4	Microsoft SQL Server	hades.lab.collation.net:1433	transactional	homeopathix.lab.collation.net:70	WebLogic Server	Limited Function	(0.4,0.5)	(0.3,0.5)	(0.2,0.6)			700	4000
L5	Windows Computer System	hades.lab.collation.net	service	hades.lab.collation.net:1433	Software Component	Slow Response	(0.8,0.1)	(0.6,0.3)	(0.7,0.3)	(0.7,0.3)	(0.6,0.3)	1000	8100
L6	Intel® PRO/1000 MT	Intel PRO/1000 MT Network 2	service	hades.lab.collation.net	Computer System	Limited Function	(0.5,0.4)			(0.6,0.3)	(0.7,0.3)	300	1800
L4	Sybase Adaptive Server IQ	brutus.lab.collation.net:2638	transactional	homeopathix.lab.collation.net:70	WebLogic Server	Slow Response	(0.8,0.1)	(0.6,0.3)	(0.7,0.3)	(0.5,0.3)	(0.7,0.3)	1000	7500
L5	Sun Sparc Computer System	brutus.lab.collation.net	service	brutus.lab.collation.net:2638	Software Component	Slow Response	(0.5,0.4)	(0.7,0.3)	(0.8,0.1)			700	7000
L4 L5	DNS/NIS service	majestix.eng.collation.net:53	service	histrionix.lab.collation.net:7021 brutus.lab.collation.net:2638 homeopathix.lab.collation:7021 whatzit.lab.collation.net:4002	Web Logic Server Sybase Server	Slow Response	(0.5,0.4)	(0.7,0.3)	(0.8,0.1)			700	7000
L5	Computer System	majestix.eng.collation.net	service	majestix.eng.collation.net:53	Software Component	Outage	(0.8,0.1)	(0.7,0.3)	(0.8,0.1)			700	7000
L3 L5	Cisco Router	aniline.lab.collation.net	service	cleopatra.lab.collation.net whatzit.lab.collation.net	Computer System	Outage	(0.5,0.4)	(0.6,0.3)	(0.3,0.5)			700	6000
L4 L5	Cisco Router	orinjade.lab.collation.net	service	homeopathix.lab.collation.net histrionix.lab.collation.net hades.lab.collation.net	Computer System	Outage	(0.2,0.6)	(0.3,0.5)	(0.4,0.5)			700	3000
L4	Switch	infarctus.lab.collation.net	service	homeopathix.lab.collation.net histrionix.lab.collation.net	Computer System	Outage	(0.2,0.6)	(0.3,0.5)	(0.4,0.5)			700	3000

Conclusion

- Managing the quality of virtualized, distributed and multi-tiered services is a hot topic in today's service research. Traditional approaches are measured bi-modal (means either operate correctly or fail) and concentrate on local technical IT performance measurements rather than with business-oriented service achievement.
- There are already more advanced approaches, including proposed models of QoS ontologies or works that are based on Fuzzy Rules e.g. Performance Relation Rules and Artificial Intelligence. The novelty of our approach lies in an integrated step-wise methodology, including automated information assimilation, support of gradual failures or service degradations (e.g. predicting a percentual SLA achievement) and bi-polar fuzzy intuitionistic impact assessments.
- Independence is not always identical with the logical negation of dependency and the measurements for independence may be totally different than those for dependencies. Only the consideration of both, positive and negative, aspects together can define the overall system behavior and the probable impact on the dependent business services
- The presented IFCFIA framework means transformation of availability and performance data into knowledge about the real-time status of business services that allows understanding and communicating the true impact of incidents on the business and vice versa.
- Within ITIL v3 best practices IFCFIA can extend Availability-, Capacity-, and Configuration Management processes by providing the gradual interdependency relationships. Within service operations the ITIL Incident- and Problem Management processes can benefit from advanced root cause determination and impact assessments by connecting IT operations to business services.
- Combining well-grounded academic research with practice oriented business scenarios by expanding IT reliability engineering with fuzzy mathematical models provides high value to the service business, especially as the framework is general enough to be applied to any type of IT service. In ongoing work, we seek to validate the IFCFIA framework by applying it to larger amounts of historical and monitored usage data compared to frontend quality parameters and business SLA's.


Questions