in real life

Architectures for Cloud Applications

Mikael Svahnberg[1]

[1] Mikael.Svahnberg@bth.se
School of Computing
Blekinge Institute of Technology

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Outline

- Recap
  - Software Architectures
  - Cloud Relevant Quality Attributes
- Architecture Implications
  - Scalability
  - Reliability/Availability
  - Performance
  - Security
  - Privacy
  - Cost Optimisation
  - Maintainability / Developability
- Summary

Software Architecture Defined

- First Definition: Boxes and Lines
  - What is the nature of the elements (boxes)?
  - What are the responsibilities of the elements?
  - What is the siginificance of the connections (lines)?
  - What is the significance of the layout?
- Second Definition: Add semantics (provide legend)
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  - What are the interfaces of the elements?
  - How does the architecture operate at runtime?
  - How do we build it?
- Third Definition:

  The software architecture of a program or computing system is the structure or structures of the system, which comprise software elements, the externally visible properties of those elements, and the relationships among them.

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Architecture Decisions

- Balancing all stakeholders result in a number of *Business and Technical Decisions*
- Software architecting is about identifying which decisions are necessary, and finding solutions that satisfy all stakeholders.

Decisions *are* the Architecture

I would go as far as to say that these decisions *are* the architecture. . . . The rest is just an instantiation of the architecture.

Influences on Architecture

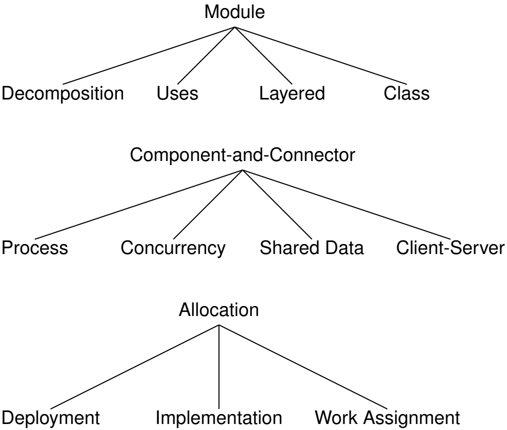
- Customer Requirements, of course
- Developing Organisation
  - e.g., business goals
  - Organisational structure
  - Available expertise (the architect’s experience)
- Technical Environment

A “Good” Software Architecture

- Is based on *conscious* decisions
- Is *evaluated* to ensure that it satisfies the specific goals for the system
- Pays attention to current and future *quality attributes*
- Is well *documented*, with traceability to the architecture decisions
- Features well defined *modules*(components), with well defined *interfaces* and well defined *responsibilities*
- Is restricted to a small set of interaction patterns that are *consistently* used.

Structures and Views

Bass et al.(2012):



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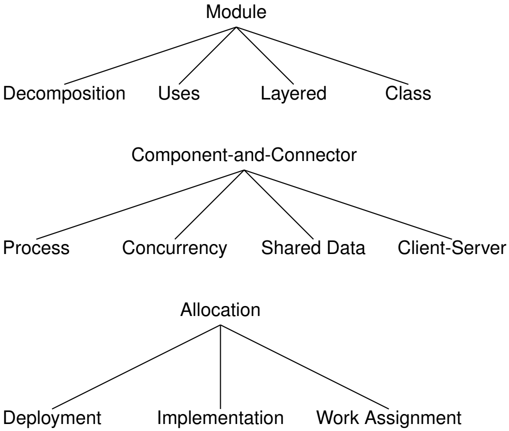


Module

Decomposition

Uses

Layered

Class

Component-and-Connector

Process

Concurrency

Shared Data

Client-Server

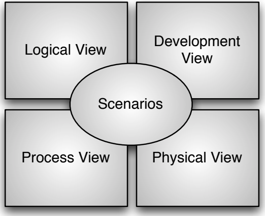
Allocation

Deployment

Implementation

Work Assignment

Kruchten(1994):



Logical View

Development View

Scenarios

Process View

Physical View

Structures and Views

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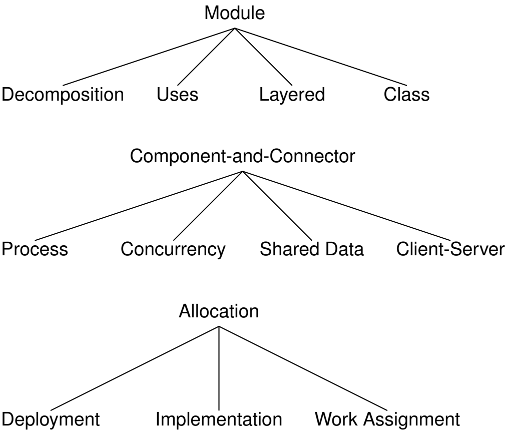

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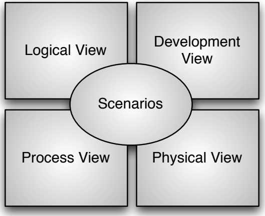

Hofmeister et al.(2000) uses a variant of this:

- Conceptual View
- Module View
- Execution View
- Code View

Architecture and Quality Attributes

- Functionality is “easy” to implement.
- Quality requirements may *sometimes* have impact on the implementation
- More often, it impacts the *software structure* (=the software architecture).
- . . . And yet, the architecture can only describe a *potential* for achieving a particular quality level.

Outline

Recap

- Software Architectures
- Cloud Relevant Quality Attributes

Architecture Implications

- Scalability
- Reliability/Availability
- Performance
- Security
- Privacy
- Cost Optimisation
- Maintainability / Developability

Summary

Factors that “push” you towards the cloud

- Transference – Move your on-site solution as-is to the cloud for e.g. economic reasons.
  - Challenges: Setting up a similar environment in the cloud as you have locally.
- Internet Scale – Scaling up to handle more users.
  - Challenges: Database design may become a bottleneck.
- Burst Compute – Large swings in capacity requirements.
  - Challenges: Strategy for load balancing, database access.
- Elastic Storage – Scaling up to handle (much) more data.
  - Challenges: need also to consider where the data is processed.

Cloud Relevant Quality Attributes

- Scalability
- Reliability / Availability
- Performance
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Architecture Implications

- This is a boring part of the lecture.
- Basically, we go through each of the cloud relevant quality attributes and discuss the corresponding tactics.

Important

The most important thing for you to think about, and for us to discuss is:

How would I address these issues and tactics in my Software Architecture?

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Scalability

- Horizontal Scaling – add more nodes
- Vertical Scaling – increase capacity of nodes
- In a Cloud system, you would do both.
    - It is easier to scale vertically unless you already have a horizontally scaled solution
    - Storage space is often easier to deal with by scaling verically – unless you already have a horizontally scaleable solution in place.

Scalability Tactics

Bass et al. does suprisingly not have any tactics associated with Scalability. They list the following tactics for *Performance*:

- Control Resource Demand
- Manage Resources

Scalability Tactics

Bass et al. does suprisingly not have any tactics associated with Scalability. They list the following tactics for *Performance*:

- Control Resource Demand
  - Manage Sampling Rate
  - Limit Event Response
  - Prioritise Events
  - Reduce Overhead
  - Bound Execution Times
  - Increase Resource Efficiency
- Manage Resources

Scalability Tactics

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- Control Resource Demand
- Manage Resources
  - Increase Resources
  - Introduce Concurrency
  - Maintain Multiple Copies of Computation
  - Maintain Duplicate Copies of Data
  - Bound Queue Sizes
  - Schedule Resources

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Discussion

What else can be done to support scalability *in the application*?

in real life

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Summary

Reliability/Availability

- Primary tools: Redundancy, Geographical (and provider) distribution, load balancing.
- Cloud solutions allows for an informed trade-off between programming reliability in, and throwing redundant servers at the problem.
- Some Cloud Providers' only availability promise is that *your node will fail after some unspecified time*!
- Connected to data persistence, since you cannot expect a “responsible” node shutdown.

Availability Tactics

Bass et al. list the following Availability Tactics:

- Detect Faults
- Recover from Faults
- Prevent Faults

Availability Tactics

Bass et al. list the following Availability Tactics:

- Detect Faults
  - Ping/Echo
  - Monitor
  - Heartbeat
  - Timestamp
  - Sanity Checking
  - Condition Monitoring
  - Voting
  - Exception Detection
  - Self-Test
- Recover from Faults
- Prevent Faults

Availability Tactics

Bass et al. list the following Availability Tactics:

- Detect Faults
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    - Preparation and Repair
    - Reintroduction
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- Detect Faults
- Recover from Faults
    - Preparation and Repair
        - Active Redundancy
        - Passive Redundancy
        - Spare
        - Exception Handling
        - Rollback
        - Software Upgrade
        - Retry
        - Ignore Faulty Behaviour
        - Degradation
        - Reconfiguration
    - Reintroduction
- Prevent Faults

Availability Tactics

Bass et al. list the following Availability Tactics:

- Detect Faults
- Recover from Faults
    - Preparation and Repair
    - Reintroduction
        - Shadow
        - State Resynchronisation
        - Escalating Restart
        - Non-Stop Forwarding
- Prevent Faults

Availability Tactics

Bass et al. list the following Availability Tactics:

- Detect Faults
- Recover from Faults
- Prevent Faults
    - Removal from Service
    - Transactions
    - Predictive Model
    - Exception Prevention
    - Increase Competence Set

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Which of these would be particularly relevant in a cloud application? Why?

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Summary

Performance

- The way you tackle performance depends very much on what type of performance you are after.
- For example,
  - Response time is very different from
  - Processing time, which is very different from
  - Storage capacity
- [In many applications] you probably have a mixture of many different requirements.

Example: Web application

- Response time: System must feel “snappy”
- Processing time: Behind the scenes, you may have activities that takes several seconds to perform.
- For example, submitting a post in a discussion forum may include:
  - Re-baking the user’s profile
  - Looking for cross-posts and re-baking these posts
  - Re-generate a thread summary
  - . . .
- In a sufficiently frequented forum, each of these actions may take several seconds to perform.

Example: Cloudbursting

- At the other end of the spectrum you have batch-processing applications
- You use the cloud's computing resouces to (re-) generate massive amounts of data.
- Response time is not an issue

Performance Tactics

- Control Resource Demand
- Manage Resources

Performance Tactics

- Control Resource Demand
  - Manage Sampling Rate
  - Limit Event Response
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in real life

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Summary

Security

- Security from External threats
- Security from threats inside the cloud provider
  - Covert channels between your VM and others'
  - Sniffing network communication
  - Inherently unsafe designs (e.g. Amazon S3's global namespace for their buckets)
  - Legal issues

Security Tactics

Bass et al. list the following Security Tactics:

- Detect Attacks
- Resist Attacks
- React to Attacks
- Recover from Attacks

Security Tactics

Bass et al. list the following Security Tactics:

- Detect Attacks
    - Detect Intrusion
    - Detect Service Denial
    - Verify Message Integrity
    - Detect Message Delay
- Resist Attacks
- React to Attacks
- Recover from Attacks

Security Tactics

Bass et al. list the following Security Tactics:

- Detect Attacks
- Resist Attacks
  - Identify Actors
  - Authenticate Actors
  - Authorise Actors
  - Limit Access
  - Limit Exposure
  - Encrypt Data
  - Separate Entities
  - Change Default Settings
- React to Attacks
- Recover from Attacks

Security Tactics

Bass et al. list the following Security Tactics:

- Detect Attacks
- Resist Attacks
- React to Attacks
  - Revoke Access
  - Lock Computer
  - Inform Actors
- Recover from Attacks

Security Tactics

Bass et al. list the following Security Tactics:

- Detect Attacks
- Resist Attacks
- React to Attacks
- Recover from Attacks
    - Maintain Audit Trail
    - Restore
    - (See Availability)

Security Tactics

Bass et al. list the following Security Tactics:

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Discussion

- Which tactics can you automate? How?
- This covers external threats. What about the threats from inside the cloud provider?

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Privacy

- *Extremely* important
- The easiest way to get bad publicity is to neglect privacy
- Often regulated by law.
- Local laws, that may differ between countries.
- Ties in with Security: Low security makes it harder to enforce privacy

Privacy Tactics

Not covered by Bass et al. Generic guidelines include:

- Restrict Stored Personal Information
  - What information do you need to store about your users?
  - Why?
  - For how long?
- Encrypt Data
- Use Secure Connections
- Hire a lawyer!
  - Strange as this may seem, this is a cost optimisation. If you do not have to have a replica of your system in each country you cater for just to satisfy local laws, the cost of the lawyer will be recovered quite quickly.

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Cost Optmisation

- The whole purpose of a cloud solution is to optimise CAPEX vs OPEX.
- The easy solution is to throw more resources at the problem.
- For obvious reasons, this is not a sustainable solution long-term.
- *However*, there is a trade-off between how much time your developers should spend on optimising your application and the cost of adding an extra, or a larger cloud resource.

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Maintainability / Developability

- Not a cloud issue *per se*, but becomes more obvious when you are paying for uptime.
- Each of your developers need a development platform (as usual)
- Test Environment
  - How many test platforms do you need to support? One per developer? One per team?
  - How do you provide this? Local Virtual Boxes? On the Cloud?
- Staging Environment
  - As close to your deployment platform as possible
  - For extensive “release-testing”
  - How many do you need? Is one enough?
  - How do you test the system in the staging environment? Do you need to have a test harness environment too?
- Deployment Environment
  - Do you have just one deployment environment? Or is it one per customer?
  - How do you elastically scale this environment? How is this reflected in the staging/testing/development environments?

Supporting different Environments

- How do you construct your application such that you can move seamlessly between the different environments?
- How do you construct your application to support automated builds and tests?

Summary

- Certain Quality Attributes are more relevant than others for a Cloud Application
- You must first find your particular blend of quality attributes
- After this, designing a cloud application is similar to designing the architecture for any other system.
- The Execution View (and hence the Module View) plays a more significant role
  - Quite Obviously; this is the factor that has changed.
- Pay extra attention to *privacy*, and your development environment