

The latest developments in advanced architectural patterns: a survey

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Abstract—In this document, the common software architectural patterns are briefly discussed. The document further describes latest advancements in service oriented architecture, microservices, reactive programming and resilient software development.

Index Terms—SOA, microservice, reactive programming, resilient software

I. ARCHITECTURAL DESIGN PATTERNS

Large enterprise needs software that scales with ever changing and increasing needs of the business. Selecting the right architecture before diving into the actual work is crucial to the success of the application and enterprise. This section explores various architectural patterns used in the industry. The pros and cons will be discussed for each of the pattern.

A. Layered architecture

It is the most common architecture style, that organize similar modules into horizontal layers. The layers are independent of others and interact using exported APIs. An application can be designed using any number of layers. The network protocol stack is a good example of layered architecture. The in upper layer is transmitted to lower layers using encapsulated packets. A layer don't have to know the inner working of other layer and communication happens through a set of APIs exposed by each layer. Another example of business application, that is divided into presentation, logic and data tiers. Following of some of the benefits offered by this architecture.

- Layers can be developed and tested independently.
- Changes made in one layer doesn't affect the other layer, hence maintainable.
- Low coupling and high cohesion
- Lower layers have no dependency on higher layer and hence reusable.

The disadvantages can be summarized as follow.

- A change to any component may trigger a redeployment of the entire application.

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- Each layer can have separate physical deployment or an entire application can be replicated. It is too coarse grained from deployment perspective.
- Communication across layers can be a performance bottleneck for certain applications.

B. client-server architecture

It consists of a server and multiple clients. The server keeps listening to the client requests. The server responds to any new client requests i.e., provides a service to those clients. E.g. the encryption key control server provides encryption keys to the requesting clients over network. This model is prone to denial of service attack. The scalability requires replicating the server components with load balancing, failover and failback mechanisms.

C. Pipe and filter architecture

This approach is suitable for large applications that can be broken down to multiple steps. Each step refers to a filter. The filter applies a specific function to the data and can work asynchronously as well. The pipes refer to the connectors between these filters. The output of one filter serves as an input for the next filter on the pipeline. The common example is Unix pipes.

- Adding a new step is easy by adding a new filter and adding it to existing pipe stream.
- It is easier to reuse of filters doing generic actions.
- Promotes concurrency of different filters do not depend on each other.
- The errors gets propagated across the filters, which is a downside of this architecture.
- A broken filter leads to a complete broken pipe.

D. Peer to peer architecture

A peer-to-peer (P2P) architecture consists of a decentralized network of peers i.e. nodes. Unlike client-server architecture, a node in this architecture can act both as a server and a client. The workload is split into small chunks that can be reassembled later, allowing peers to work simultaneously on

a task. E.g. P2P file sharing, where a file is split into chunks that allows many chunks to be downloaded from different peers at the same time.

- Need for centralized server is eliminated.
- There is no single point of failure, unless the number of peers are too few.
- The increase in number of peers can be handled easily i.e., scalable.
- The model is prone to security issue, as an infected peer can affect the whole network.
- Fairness guarantees are difficult to enforce as many leeches could benefit free riders.
- Instant messaging, file sharing, collaboration apps use P2P architecture. E.g. Bitcoin, BitTorrent, napster etc.

E. Event based architecture

The callbacks mechanism describes this architecture well. It consists of source, listener, and a bus. The event source send a message i.e. an event on the bus to other component. The listener responds by performing some action. The components communicate only via the event bus. The linux device driver interrupt handlers employ this mechanism.

- Changing name or type of an event requires changes to the listener.
- Too many event sources or listeners lead to bottleneck for the bus.
- Following the control flow is difficult due to asynchronous nature of events.
- The producer and consumer of the event need not be aware of each other allowing for loose coupling
- Loose coupling makes it easy for a component to evolve independently.
- Message passing over the bus introduce additional abstraction and may not be efficient.

F. Interpreter

It consists of a program to be executed, an interpreter which runs such a program, program state and memory component required any storage needs. The interpreted languages like Awk, Perl, Python or Java are prime example of this architectural style of development.

- Program development becomes easy with the help of interpreter.
- Allows portability across various platforms.
- Debugging become easier.
- An extra level of indirection makes execution slower.
- Interpreter can guard against malicious instruction

G. Blackboard

It is similar to boardroom where people solve the problem using a whiteboard. The component blackboard acts as a global information store. It allows various components to collaborate towards the final solution. The controller component monitors the blackboard and schedules individual knowledge sources. The knowledge sources are specialized workers with its own representation of the problem. The communication

happens through the blackboard. The CAD software is an example of blackboard design.

- Efficient scheduling of tasks and resource management across a distributed network.
- Better suited when a problem can be split into multiple sub-problems.
- Not always easy to break down a task into subproblems.
- Everything is shared and can cause unwanted information flows.
- Controller design can become overly complex and un-maintainable.
- Knowledge sources being independent, allows for reusability.

H. Publish Subscribe Architecture

II. NEW ARCHITECTURAL STYLES

This section looks at various recent advancements in the software architecture. Following patterns are discussed exclusively.

- Service Oriented architecture (SOA)
- Microservices
- Containers
- Reactive programming
- Resilient software development

A. SOA

B. Microservices

C. Containers

D. Reactive programming

E. Resilient software development

F. Units

- Use either SI (MKS) or CGS as primary units. (SI units are encouraged.) English units may be used as secondary units (in parentheses). An exception would be the use of English units as identifiers in trade, such as “3.5-inch disk drive”.
- Avoid combining SI and CGS units, such as current in amperes and magnetic field in oersteds. This often leads to confusion because equations do not balance dimensionally. If you must use mixed units, clearly state the units for each quantity that you use in an equation.
- Do not mix complete spellings and abbreviations of units: “Wb/m²” or “webers per square meter”, not “webers/m²”. Spell out units when they appear in text: “. . . a few henries”, not “. . . a few H”.
- Use a zero before decimal points: “0.25”, not “.25”. Use “cm³”, not “cc”.)

G. Equations

Number equations consecutively. To make your equations more compact, you may use the solidus (/), the exp function, or appropriate exponents. Italicize Roman symbols for quantities and variables, but not Greek symbols. Use a long dash rather than a hyphen for a minus sign. Punctuate

equations with commas or periods when they are part of a sentence, as in:

$$a + b = \gamma \quad (1)$$

Be sure that the symbols in your equation have been defined before or immediately following the equation. Use “(1)”, not “Eq. (1)” or “equation (1)”, except at the beginning of a sentence: “Equation (1) is . . .”

H. *L^AT_EX-Specific Advice*

Please use “soft” (e.g., `\eqref{Eq}`) cross references instead of “hard” references (e.g., (1)). That will make it possible to combine sections, add equations, or change the order of figures or citations without having to go through the file line by line.

Please don’t use the `{eqnarray}` equation environment. Use `{align}` or `{IEEEeqnarray}` instead. The `{eqnarray}` environment leaves unsightly spaces around relation symbols.

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I. *Some Common Mistakes*

- The word “data” is plural, not singular.
- The subscript for the permeability of vacuum μ_0 , and other common scientific constants, is zero with subscript formatting, not a lowercase letter “o”.
- In American English, commas, semicolons, periods, question and exclamation marks are located within quotation marks only when a complete thought or name is cited, such as a title or full quotation. When quotation marks are used, instead of a bold or italic typeface, to highlight a word or phrase, punctuation should appear outside of the quotation marks. A parenthetical phrase or statement at the end of a sentence is punctuated outside of the closing parenthesis (like this). (A parenthetical sentence is punctuated within the parentheses.)

- A graph within a graph is an “inset”, not an “insert”. The word alternatively is preferred to the word “alternately” (unless you really mean something that alternates).
- Do not use the word “essentially” to mean “approximately” or “effectively”.
- In your paper title, if the words “that uses” can accurately replace the word “using”, capitalize the “u”; if not, keep using lower-cased.
- Be aware of the different meanings of the homophones “affect” and “effect”, “complement” and “compliment”, “discreet” and “discrete”, “principal” and “principle”.
- Do not confuse “imply” and “infer”.
- The prefix “non” is not a word; it should be joined to the word it modifies, usually without a hyphen.
- There is no period after the “et” in the Latin abbreviation “et al.”.
- The abbreviation “i.e.” means “that is”, and the abbreviation “e.g.” means “for example”.

An excellent style manual for science writers is [7].

J. *Authors and Affiliations*

The class file is designed for, but not limited to, six authors. A minimum of one author is required for all conference articles. Author names should be listed starting from left to right and then moving down to the next line. This is the author sequence that will be used in future citations and by indexing services. Names should not be listed in columns nor group by affiliation. Please keep your affiliations as succinct as possible (for example, do not differentiate among departments of the same organization).

K. *Identify the Headings*

Headings, or heads, are organizational devices that guide the reader through your paper. There are two types: component heads and text heads.

Component heads identify the different components of your paper and are not topically subordinate to each other. Examples include Acknowledgments and References and, for these, the correct style to use is “Heading 5”. Use “figure caption” for your Figure captions, and “table head” for your table title. Run-in heads, such as “Abstract”, will require you to apply a style (in this case, italic) in addition to the style provided by the drop down menu to differentiate the head from the text.

Text heads organize the topics on a relational, hierarchical basis. For example, the paper title is the primary text head because all subsequent material relates and elaborates on this one topic. If there are two or more sub-topics, the next level head (uppercase Roman numerals) should be used and, conversely, if there are not at least two sub-topics, then no subheads should be introduced.

L. *Figures and Tables*

a) *Positioning Figures and Tables:* Place figures and tables at the top and bottom of columns. Avoid placing them in the middle of columns. Large figures and tables may span

across both columns. Figure captions should be below the figures; table heads should appear above the tables. Insert figures and tables after they are cited in the text. Use the abbreviation “Fig. 1”, even at the beginning of a sentence.

TABLE I
TABLE TYPE STYLES

Table Head	Table Column Head		
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^aSample of a Table footnote.



Fig. 1. Example of a figure caption.

Figure Labels: Use 8 point Times New Roman for Figure labels. Use words rather than symbols or abbreviations when writing Figure axis labels to avoid confusing the reader. As an example, write the quantity “Magnetization”, or “Magnetization, M”, not just “M”. If including units in the label, present them within parentheses. Do not label axes only with units. In the example, write “Magnetization (A/m)” or “Magnetization {A[m(1)]}”, not just “A/m”. Do not label axes with a ratio of quantities and units. For example, write “Temperature (K)”, not “Temperature/K”.

ACKNOWLEDGMENT

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Number footnotes separately in superscripts. Place the actual footnote at the bottom of the column in which it was cited. Do not put footnotes in the abstract or reference list. Use letters for table footnotes.

Unless there are six authors or more give all authors’ names; do not use “et al.”. Papers that have not been published, even if they have been submitted for publication, should be cited as “unpublished” [4]. Papers that have been accepted for publication should be cited as “in press” [5]. Capitalize only the first word in a paper title, except for proper nouns and element symbols.

For papers published in translation journals, please give the English citation first, followed by the original foreign-language citation [6].

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