

Mathematical Induction

- *Deductive reasoning* ties the whole of mathematics. For example, take this problem from highschool: solve for y where $y = x^2 - 8$ and $x = 10$. We are using the information given by the equation and x to *deduce* the value y .
- Deductive reasoning in mathematics is given in the form of *proofs*.
- Unproven hypothesis that is known to hold = *conjecture*.

An example of deductive reasoning:

1. It will either rain or snow tomorrow. It is too warm for a snow. Therefore, it will rain tomorrow.

The argument universe is important.

Think of argument as an environment where an arguer assumes the truth value of premises and argues for a given conclusion. That means the “truth” of the statements in the universe is not considered and what matters most the *validity* for the logic flow.

We talk of premise in the context of arguments. Otherwise it is simple statements and compound statements. The truthiness of compound statement depends on the truthiness of its component statements and the logical connectives between them.

Example analyze the logical form of the following statement:

Either Bill is at work and Jane isn't, or Jane is at work and Bill isn't.

$$(P \wedge \neg Q) \vee (Q \wedge \neg P)$$

General form of deductive reasoning:

1. Logically connected statement or premise. It is more interesting when the connective is OR or IMPLIES.
2. A premise assumed to be true or false.
3. A conclusion.

Proof. Here is my proof:

$$a^2 + b^2 = c^2$$

□

Truth tables

We talk of premise in the context of arguments. Otherwise it is simple statements and compound statements. The truthiness of compound statement depends on the truthiness of its component statements and the logical connectives between them. ¹

¹This is very important—context

P	Q	$\neg P$	$\neg Q$	$P \vee Q$	$P \wedge Q$
T	F	F	T	T	F
T	T	F	F	T	T
F	T	T	F	T	F
F	F	T	T	F	F

OR can be both inclusive (P or Q, or both) or exclusive (P or Q, not both). keep in mind. In mathematics, we all ways mean inclusive OR.

Writing (English)

Grammar

The most important part of a sentence that I need to keep an eye out for is the verb phrase². Verb phrases are the heartbeat of a sentence. Noun phrases draw power from verb phrases. Noun phrases derive meaning from verb phrases. Almost everything else in a sentence is a modifier. One word may belong to many parts of speech. There is no function like relationship between words and parts of speech³. English follows the SVO (subject–verb–object) sentence pattern. The placement of words in a sentence is a more reliable way to tell the function of that word in a sentence.⁴ For example, take a look at the following two sentences:

- *Winter* is harsh.
- Thomasia *winters* in Tuscon.

The same word *winter* represents two different parts of speech in each of the above sentences. In the first sentence⁵, it is used as noun phrase that functions as a subject. In the second sentence, it is used as a verb. Verbs have the unique ability of “travelling” through time (present, past, and future) which we call *tense*. Verb is the only part of speech that can encode/decline tense in its form.

- Todd *arrives* in Tuscon.
- She *had* a drink.
- She *has* the baby.

In the above set of sentences, the verb phrases carry both the action and the actions period. Verb phrases are a combination of auxiliaries and other verbs. The combination accomplishes showing time and mood that a single word is not able to. For example:

- Kaput *ate* before leaving the house.

²The noun phrase modifier *that I need to keep an eye out on* is relative clause modifier, and the main verb phrase is *is*

³*is* is acting like a link verb between the pronoun *There* and *no function like relationship...* which is a subject complement

⁴This sentence is a little more tricky to analyze, but form wise, it is similar to the sentence *The placement of cars in a garage is great*. Its form is thus *NP – LV – SC*, and *of words in a sentence* is a prepositional phrase

⁵*In the first sentence* is a whole sentence modifier.

- Kaput *should have eaten* before leaving the house.
- By the time we get there, he *will have been **blowing up*** at the referee for quite some time.

The single word verb phrase *ate* conveys the simple past and *to eat* in its conjugation. the multi-word verb phrase *should have eaten* conveys an additional mood *should have* with its root action. *blowing up* is *verbal phrase* that is made up of two words but actually represents a new word with a different meaning. single verb phrases can form sentence. *Stop!* is a single verb phrase sentence. some verbs are transitive:

Pat sent *Chris* the message.

Julia *smells* bad.

Lisa *is smelling* to Pizza.

Mr. Becker *is* a big man.

verbs can be transitive or non transitive. transitive verbs can take objects. in the above sentence *the message* is direct object while *Chris* is indirect object. *linking verbs* tell more about their subjects. *smells* in the second sentence is a linking verb telling us more about *Lisa*. what comes after the linking verb is called the *subject complement*. subject complements are of two kinds: they can be *modifiers* or they can be other noun phrases. a rule of thumb to identify nouns is to check if the noun can take an article. articles are a type of determiners. determiners: *the, that, some, some, a, ...*

$$NP = (D + M_0 + N + M_1) + C + NP$$

where *NP* is a noun phrase, *D* is a determiner, *M₀* is a modifier before the noun, *M₁* is a modifier after the noun, *C* is conjunction, and *N* is a noun. *Some big, white, dependable **chickens** besides the red wheelbarrow and a delicate glaze of **rainwater**.*

The squeamish are nervous.

*The enormous, fancy **Taco*** is thrown away.

*The **man** in yellow hat* kicked the lady

*A disastrous **event** that left many dead...*

traditionally, *squeamish* is used as an adjective but its placement in the above sentence makes it work as noun representing the subject. in the second sentence *The* represents the determiner, *enormous, fancy* is the modifier and *Taco* is the root subject.

modifiers modify verb and noun phrases. verb phrase modifiers may appear before the verb or after the verb. single word modifiers end with *-ly* but not always. example of multi word modifier is *prepositional phrases*. example below sentence 4.

The gazelle runs *fast*.

Sammy sings *pretty*.

Sam sings *good*.

Sam sings *well*.

Elyssa fished *under the full moon*.

Frita fished *while her friend cooked*.
 The incomparable June had *wisely* hunted *only on Thursdays*.
 The suspects *often* look suspicious.

the noun phrase is the most modifyable part of a sentence. noun phrase modifiers can appear before or after the noun.

This *cold, super sweet, photogenic banana* **ice cream** *on the table (last night's table desert) forgotten after the party and sitting in the sun and which we really did mean to go back to* is ruined.

one of the modifiers that come after the noun, *on the table* is a prepositional phrase. *(last night's table desert)* is an appositive. *forgotten after the party* is a participial phrase made of verbs, *sitting in the sun* is a participial phrase, made of verbs. *which we really did mean to go back to* is a relative clause noun modifier, and *ruined* that comes after the linking verb *is* is a subject complement modifier.

of the noun clauses we listed above two of them deserve attention: *relative clauses* and *complement clauses*. we modify noun phrases with relative clauses by adding another clause talking about the same subject. for example the following clauses (independent) all have the same subjects. relative clause are introduced by relativizers like *who, which, that, whom, whose*.

- *The owl* caught the squid.
- The mouse fears *the owl*.
- *The owl* hoots every night.

we can use one of the sentence above as a relative clause modifier to produce:

- The owl *that the mouse fears* caught the squid.
- The owl *that hoots every night* caught the squid.
- The mouse fears the owl *that caught the squid*.
- The mouse fears the owl *that hoots every night*.
- The owl *that caught the squid* hoots every night.
- The owl *that the mouse fears* hoots every night.

complement clauses are somewhat similar to relative clause modifiers. relative clauses added while complement clauses are complement clauses are necessary for full information. complement clauses are usually used with noun phrases like: *The idea, The thought, The recommendation, ...new*. example:

Complement: The recommendation (*that*) *we go to the park...*

Relative: The kids (*that*) *went to the park...*

complement clauses can form noun phrases on their own. for example:

Mable shouted (*the message*) *that she was ready for the debate*.

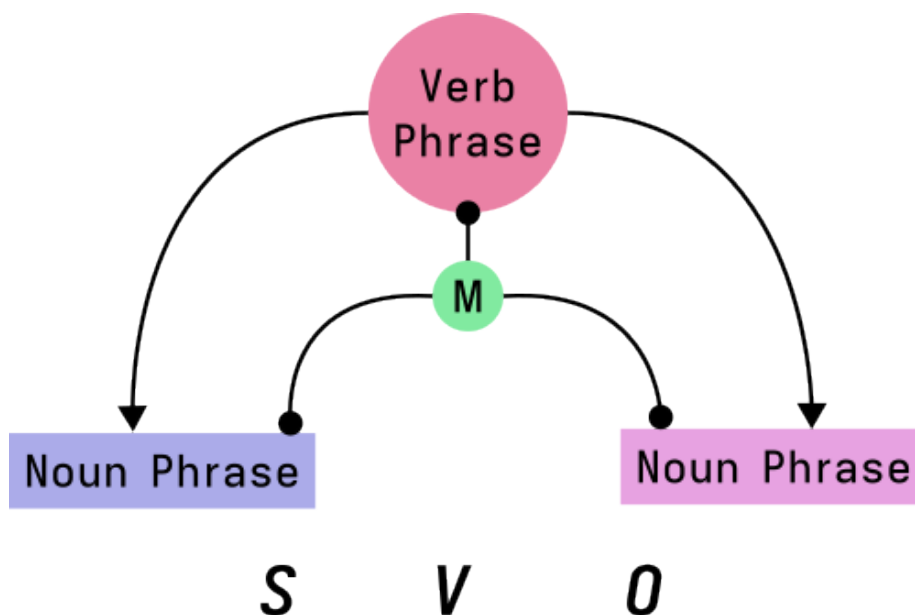


Figure 1: Typical sentence structure

(the message) that she was ready for the debate is used as a complete noun phrase acting as the object to *shouted*.

modifiers that sentences as a whole are called sentence modifiers. sentence level modifiers usually appear at the beginning of a sentence and are separated by a comma.

1. *Understandably*, Sam decided not to come.
2. *On Thursday night*, Raymond berated Madeline.
3. *Motivated by fear*, the squirrel scampered.
4. *Please*, wear your masks.
5. *Astoundingly*, the ice cream brought about world peace.
6. *Under duress*, we confessed to dismantling the planes.
7. *Responding to the news*, the detective threw a fit.
8. *When I was a child*, my father gave me licorice.

sentence number 3 is an example of multi-word modifier. sentence number 6 is an example of sentence modifier that is prepositional phrase. sentence number 7 is an example of sentence modifier that is participial phrase. the place of modifiers matters a lot.

- *Really*, the old touscan shrieked loudly at the miserable goose.
- The *really* old touscan shrieked loudly at the miserable goose.

- The old touscan *really* shrieked loudly at the miserable goose.
- The old touscan shrieked *really* loudly at the miserable goose.
- The old touscan shrieked loudly at the *really* miserable goose.

sentence can be made out of single verbs *Stop!*, single independent clause that contains noun phrase and verbe phrase *Each of the students leaving the classroom are pathetic loosert indefinately.* or from subordinated and independent clauses *After I told him to cut it out, Schmitt began to make more scene..* Subordinating clauses begin with words known as subordinatiing conjunctions. *After, Because, Although, Despite* are example of subordinating conjunctions.

{After the miserable party ended}, [Georgio boldly declared that he was the checkers champion], [but Lydia, incensed by the presumption, rejected his claim and proposed a board game coup⁶] {because she saw her opportunity to prevail⁷}. in the above complex sentence, subordinated clauses are in {} and independent clauses are in [].

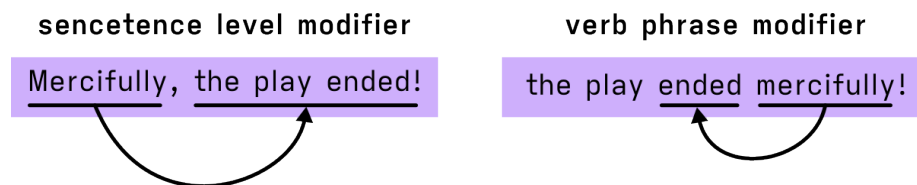


Figure 2: Sentence level and verb phrase modifiers

Comma usage recorded thus far:

1. After sentence level modifiers.
2. After subordinated clauses.
3. Between independent clauses conjugated with one of FANBOYS.

there is no agreed upon idea of what a paragraph should contain. paragraph is what start on indented line and ends a line white space. aggregation of words into whitespace separeted bunches makes paragraphs a contained unit of language. readers expect some from of structure from each of our paragraphs. *Focus* is the most expected from the paragraphs we write. each paragraph should talk about one idea only. *Topic sentences* at the start of a paragraph orient our readers on what is to follow in the paragraph so they know what expect and can follow easily. we can think of topic sentences as labels for a paragraph. human have a small working memory. make paragraph shorters and concise. a good *flows*. By flow, we mean sentences in the paragraph chain together to create effortless reading experience.

⁶*rejected his claim and proposed a board game* is a single verbal phrase with two objects attached.

⁷subordinated clauses can come after the independent clause

Infinitive		<i>wollen</i>
Present tense	ich	will
	du	willst
	es	will
	wir	wollen
	ihr	wollt
	Sie	wollen
	sie	wollen
Past tense	ich	wollte
	du	wolltest
	es	wollte
	wir	wollten
	ihr	wolltet
	Sie	wollten
	sie	wollten
Participle		gewollt

Table 1: *wollen* conjugations.

Deutsch

Phonology

Phonology is grammar of the sounds of a language, but phonetics is the study of human produced sound for its own sake.

the text below contains the translation of Rammsteins hit ich will.

- 1 ich will
- 2 ich will
- 3 ich will
- 4 ich will
- 5 ich will
- 6 ich will
- 7 ich will

ich is the first singular personal pronoun in the nominative case. the nominative case marks the subject of a verb. the other cases of the first person singular personal noun are *mich*, *meiner*, *mir* for accusative, genitive, and dative cases respectively. *will* is the singular first person present conjugation of *wollen*. *ich will* translated to english means *i want*.

- 1 Ich will dass ihr mir vertraut
- 2 (Ich will) Ich will dass ihr mir glaubt
- 3 (Ich will) Ich will eure Blicke spüren
- 4 (Ich will) jeden Herzschlag kontrollieren
- 5 (Ich will) eure Stimmen hören

<i>vertrauen</i>		
Prasens	Singular	ich vertraue du vertraust er/es/sie vertraut
	Plural	wir vertrauen ihr vertraut sie vertrauen
Präteritum	Singular	ich vertraute du vertrautest er/es/sie vertraute
	Plural	wir vertrauten ihr vertrautet sie vertrauten

Table 2: Conjugations of *vertrauen*

	Masculine	Feminine	Neuter
Nominative	jeder	jede	jedes
Accusative	jeden	jede	jedes
Genitive	<i>jedes</i>	jeder	jedes
Dative	jedem	jeder	jedem

Table 3: Declension of *jeder*

- 6 (Ich will) Ich will die Ruhe stören
- 7 (Ich will) Ich will dass ihr mich gut seht
- 8 (Ich will) Ich will dass ihr mich versteht

dass is a subordinating clause introducer similar to english's *that*. *eure* is the genitive of the second person plural *ihr* (you (all)). *jeden*⁸ is a determiner that corresponds to english *each*, *every*. *vertrauen* is a weak regular verb that translates to English as *to trust*. Since it is a weak regular verb its conjugations is simple.

- 1 I want that you (all) trust me
- 2 (Ich will) I want that you (all) believe me
- 3 (Ich will) I want your glancing look.
- 4 (Ich will) Each heartbeat controlling.

Grammar

All german nouns are “gendered”. the genders are: neutral, male and female. but the actual gender of the noun has nothing to do with its gender especially for inanimate objects. german nouns are to be memorized with the

⁸except that *jeden* (rather than *jedes*) is usual in the genitive singular masculine and neuter if the following noun has the ending -(e)s, e.g. *am Ende jed **es** (less frequent: jed **es**) Abschnitts*.

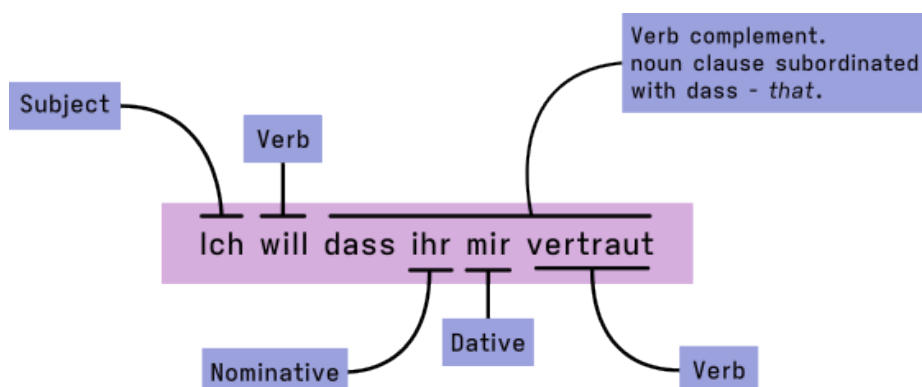


Figure 3: Verb structure for the first verse

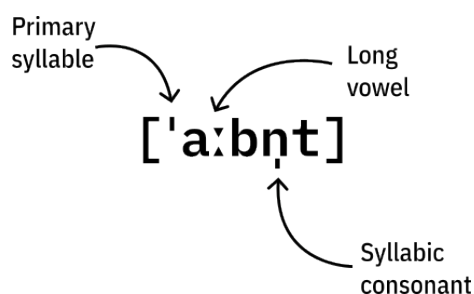


Figure 4: IPA symbols.

article reflecting the gender. These are *der*-nouns (masculine), *die*-nouns (feminine) and *das*-nouns (neuter). Examples: *das Cafe*, *der Flughafen*, *der Bahnhof*, *das Restaurant*, *das Hotel*, *die Botschaft*, *die Bank*, *die Zigarren*, *der Wein*, *das Bier*, *der Kaffee*, *der Tee*, *die Milch*, *das Wasser*, ...It makes no sense for wine to a masculine gender.

Personal pronouns

Nominative	Accusative	Genitive	Dative
ich	mich	meiner	mir
du	dich	deiner	dir
er	ihn	seiner	ihm
sie	sie	ihrer	ihr
es	es	seiner	ihm
wir	uns	unser	uns
ihr	euch	euer	euch
Sie	Sie	Ihrer	Ihnen
sie	sie	ihrer	ihnen

Table 4: Personal pronouns in Deutsch.

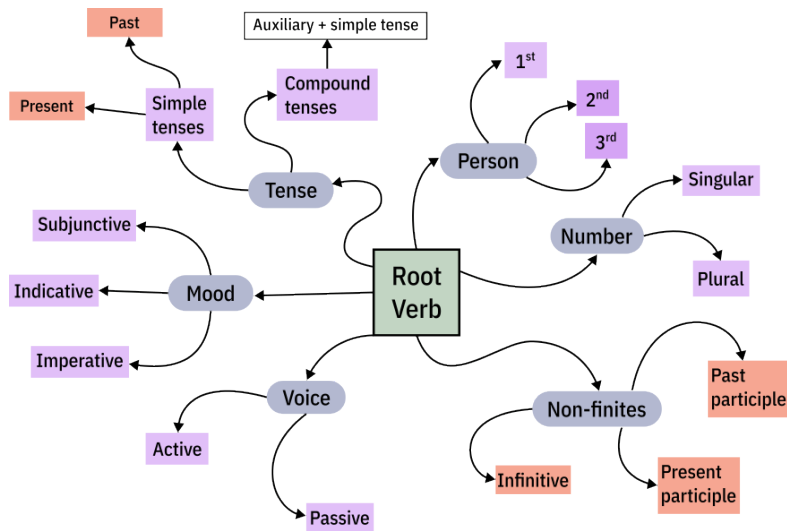


Figure 5: German verb conjugations

Unlike English verbs which are only conjugated for number, and tense, German verb conjugation depends on number, gender, person, mood, and tense. German verbs can be regular or irregular in their conjugation. Finite verbs must agree with the subject, unlike non-finite verbs.

The “principal parts” of a verb are:

1. Infinitive form.
2. Past tense form.
3. Past participle form.

Based on conjugation I need to worry about:

1. Weak verbs.
2. Strong verbs.
3. Irregular verbs.
 - (a) Irregular weak verbs.
 - (b) Irregular strong verbs.
 - (c) The modal auxiliary verbs and *wissen*.
 - (d) The verbs *haben*, *sein*, and *werden*.

Java notes

Type theory interlude

Subtyping

In programming language theory a *subtype* refers to a type that is related to another type, also called the *supertype*, by some notion of *substitutability*,

meaning that program elements typically functions (or subroutine) written to operate on the supertype can also operate on the subtype. If S is the subtype of T , the subtyping relation is often written as $S <: T$, to mean that any term of type S can safely be used in places that expect type T to be present. For example in Java, every type except for primitive types is the subtype of `Object` class. Or stated mathematically:

$$E <: O$$

Where E is every other class and O is the `Object` class.

Covariance, contravariance, and invariance

Variance refers to how the subtyping of more complex types is related to subtyping between the component types. Complex types include: generics, functions, and collections types like arrays, maps, and linked lists. For example, should `List<Cat>` be the subtype of `List<Animal>` give that type `Cat` is the subtype of type `Animal`? Does

$$L[C] <: L[A]$$

hold given that

$$C <: A$$

for a given programming language like Java? Since Java supports generics, which allow the programmer to extend the type system with new type constructors (parametric polymorphism), which raises the question should `ArrayList<File>` be the subtype of `ArrayList<Object>` (*covariant*)? Java uses *use-site* annotation to describe the variance of the generic type constructors. *declaration-site* annotation is used by C#, Kotlin, and Scala.

Within a type system of a programming language, a type rule or a type constructor is:

- *covariant* if it preserves the ordering of types (\leq), which orders types from more specific to more generic: If $C <: A$, then $I[C] <: I[A]$.
- *contravariant* if it reverses this ordering if $C <: A$, then $I[A] <: I[C]$.
- *bivariant* if both of this apply. (i.e., if $C <: B$, then $I[C] \equiv I[A]$).
- *variant* if covariant, contravariant, or bivariant.
- *invariant* or *nonvariant* if not variant.

Package management

Classes live inside packages. a package declared using `package ...`; classes living in the same package can see each other. package *classpath* and directory structure of the source must match each other. always think of two contexts the classpath context and source context. why should java source directory tree and package name classpath match? answer here. relationship with maven group id and artifact ids?

The language

Non wildcard (`G<?>`) parameterized types are invariant in Java, i.e, there is no subtyping relationship between `List<Cat>` and `List<Animal>`.⁹

Java does not suffer from template bloat like C++ does. Why? That is because C++ creates a new type for every template instantiation. For example:

```
||     template <typename T>
||     void print(T arg) {
||         // ... implementation
||     }
||
||     print<int>(30);
||     print<const char*>("Hello");
```

Essentially generates two copies of the function `print` with the type parameters resolved: `printInt` and `printConstPtrToChar` which generates bloat during compilation. Java unlike C++ generates just one type for each generic type with the generic type thrown away, which call *type erasure*.

```
||     public <T> void print(T arg) {
||         // ... implementation
||     }
```

becomes just one function with type parameters replaced with `Object` type.

```
||     public void print(Object arg) {
||         // ...implementation
||     }
```

Dependency injection

Dependency injection is a design pattern applied to classes with members so that the member are initialized outside the class itself. For example, the following code:

```
|| package io.github.termitestpreston;
||
|| public class RealBillingService implements BillingService {
||
||     @Override
||     public Receipt chargeOrder(PizzaOrder order, CreditCard
||         creditCard) {
||         CreditCardProcessor processor = new
||             PaypalCreditCardProcessor();
||         TransactionLog transactionLog = new DatabaseTransactionLog()
||             ;
||
||         try {
||             ChargeResult result = processor.charge(creditCard, order
||                 .getAmount());
||             transactionLog.logChargeResult(result);
||
||             return result.wasSuccessful();
||         }
```

⁹more on this.

```

        ? Receipt.forSuccessfulCharge(order.getAmount())
        : Receipt.forDeclinedMessage(result.
            getDeclinedMessage());
    } catch (UnreachableException e) {
        transactionLog.logConnectException(e);
        return Receipt.forSystemFailure(e.getMessage());
    }
}
}

```

`RealBillingService` class depends on two internally constructed objects inside the `chargeOrder` function. If we wanted to test `chargeOrder`, we will have to charge from a real Paypal account which is impractical. To solve this we could use:

- Using a Factory class but we would have to reset this global factory after each test.
- Passing every dependency to constructor manually. using method we can remove `setUp` and `tearDown` methods from our test code. further more expose the dependency in the api signature.
- Using a dependency injection framework.

Java is getting better and better with each release. Keep the the features listed below in mind when working with a new java project.

- better `switch` blocks.
- a smarter `instanceof` operator.
- Records with autogenerated getters, setters, and to string.
- Text blocks.
- sealed classes.

Java security primitives

Java uses several classes and interfaces from core java packages to third party libraries to help with the control of *access to information*. *Principal* interface represents an abstract notion of a principal, which can be used to represent any entity, such as an individual, a corporation or a login id. Essentially, anything with a name (that name could be a user id from user database) is principal. A *Credential* is a piece of document that details the qualification, competence, or authority issued to an individual by a third party with a relevant defacto authority assumed competence to do so. Examples of credentials include academic degrees, passwords, security clearance, badges, passwords, user names, keys, and certifications. *Subject class* represents a *grouping* of related information for a single entity, such as a person. Such information includes subjects identities as well as security related attributes (passwords, cryptographic keys, for example.) Subjects may potentially have multiple identities. Each identity is represented as

a [Principal](#) within the [Subject](#). For example a [Subject](#), that happens to be a person, Alice, might have two principals: one which binds “Alice Bar”, the name of her driver license, to the [Subject](#), and another which binds “999-99-999”, the number of her student identification card, to the [Subject](#). Both [Principals](#) refer to the same [Subject](#) even though each has different name.

```
package java.security;

public interface Principal {
    // ...
    String getName();
    boolean implies(Subject subject);
    // ...
}
```

Important Java foundations

The Eclipse foundation and Apache foundation contribute a great deal to the advancement of the Java ecosystem. Besides that Red Hat and Oracle are commercial companies engaged in the development and support of Java Platform.

Jakarta EE

Jakarta EE also previously known as Java Enterprise Edition is a set of *Specifications* that extend Java SE with specifications for enterprise features such as distributed computing and web services. Jakarta EE defined by its specification, and its specification defines APIs and their interaction. Jakarta EE was maintained by Oracle corporation who later transferred its development to Eclipse foundation was renamed from Java EE to Jakarta EE because Oracle owns the trademark for *Java*.

OSGi

OSGi specification describes a modular system and service platform for Java that implements a complete and dynamic component model, something that does not exist in standalone Java/VM platforms. In enterprise settings typical Java application is not packaged as jar and launched from its main function using the system installed java executable, rather than that the enterprise system provides a java platform that *always* runs in which application bundles are loaded and unloaded without restarting the application server. OSGi architecture has the following components:

1. *Bundles* are normal JAR components with extra manifest headers.
2. *Services* layer connects bundles in a dynamic way by offering a publish-find-bind model for POJIs and POJOs.
3. *Service registry* the application programming interface for management services.

4. *Life-cycle* the application programming interface for lifecycle management (install, start, stop, update, uninstall) for bundles.
5. *Modules* layer defines encapsulation and declaration of dependencies (how bundles can import and export code).
6. *Security* layer that handles the security aspects by limiting bundle functionality to pre-defined capabilities.

Apache Felix is implementation of the OSGi specification.

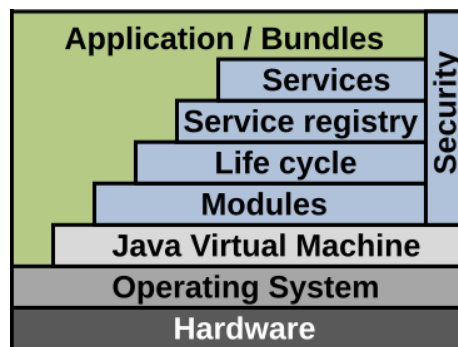


Figure 6: OSGi architecture.

Glassfish

JAX-RS

Jakarta RESTful Web Services also called *JAX-RS* is a set of interfaces and annotations included in Java EE platform that help in writing REST applications. Since JAX-RS is just a collection of interfaces and annotations it just defines an API. RestEasy from Red Hat, Jersey from Eclipse foundation and Apache CXF are the libraries implementing the API.

Root resource classes are POJOs that are annotated with `@Path` have at least one method annotated with `@Path` or a resource method designator annotation such as `@GET`, `@POST`, `@PUT`, or `@DELETE`. Resource method are methods of resource class that are annotated with resource method designator.

Java world is full of specifications and implementations (some of which are reference). Language features such as interfaces, annotations and abstract base classes aid writing specifications in java code.

The server

Traccar server is a 3 layer monolithic application where each layer handles a specific functionality¹⁰. The top layer in the application receives incoming request from mobile and application clients as well as both http and

¹⁰If this is the topic sentence, then the rest of the paragraph should be about some sort of layering.

websocket connection. The middle layer of the application processes these requests and performs business logic before the third layer persists or reads objects to a database.

The top layer of Traccar is composed of a set of servlets. One of the servlets handles incoming REST API (Application Programming Interface) calls from mobile and web clients. The other servlets handle websocket communication with tracking devices and serving media files for web clients. Since almost all of our modification is related to business logic and authorization related stuff, we will focus on the REST API servlet.

The REST API servlet implements the Jakarta RESTful Web Services (JAX-RS) specification. JAX-RS specification provides its users with annotations to decorate their classes. Traccar server uses Eclipse Jersey as the implementation library of JAX-RS. REST API resources are bound to handler classes with annotations. Each handler class is annotated with REST API resource *path*. Annotated functions in the resource class handle specific HTTP methods. This layer of the application is commonly called the controller. Jersey takes FasterXML's Jackson JSON serialization/deserialization library in its filter chain to convert incoming JSON payloads to the application objects.

Before each request is received by the resource handler classes, it passes through a class that implements JAX-RS' `ContainerRequestFilter` interface. This interface contains the `filter` function. The `filter` function allows us to perform custom logic on all requests before they are matched with and dispatched to our resource handler classes. Our implementation of the interface checks if each request contains a JSON Web Token (JWT) payload in the `Authorization` header, and if the header is present it tries to decode it and retrieve a valid Firebase user using Firebase Admin library functions.

Another function of our class implementing `ContainerRequestFilter` is to inject objects that are useful for processing incoming requests. It injects a `SecurityContext` object for use by our resource handler classes. The injected object contains authentication information necessary for the logic inside our resource handlers. One such information is the user's unique identifier ID decoded from the JWT payload.

`Storage` class is also injected into the resource handlers. `Storage` interfaces with the underlying database to write and read application objects in memory. Connection to the underlying database is managed by HikariCP connection pool management library. We manage our connections with HikariCP because we want to be resource efficient. We become resource efficient by not recreating database connection for every request but by storing and reusing connections from older completed requests. By doing connection pooling, we reduce object creation/destruction overhead.

Traccar server uses Liquibase database migration tool to automatically initialize tables on startup. Liquibase reads table creation data from *schema* files written in XML. Each schema file is written in the form of *changesets*. *changesets* help us in the process of restoration of older database state. Traccar server uses a custom Object Relational Mapping (ORM) system. Each Traccar model class we want to persist is annotated with `@StorageName`. `@StorageName` helps the ORM to generate column names and table names using Java's support for runtime reflection. By using annotations and reflection, we can load database table rows to application memory objects of a classes

that are annotated with `@StorageName` or insert objects that are annotated with `@StorageName("table_name")` to database rows. Each of the API handlers use instance of `Storage` class to read and write persistence data. Traccar's in house ORM replaces right hand side of a `where` clause with a variable.

```
1  -- notice the :id? it is a variable not a concrete value. May be it
   ~ is a JDBC thing?
2  select * from ipk_user as u where id = :id;
```

Data managers sit between `Storage` class and our resource handlers to facilitate the implementation of a more complex logic. This more complex logic is usually a code that shares functionality with the websocket code.

Objects in Traccar server are linked with each other post creation. Special tables in the database store this linkage information. `Permission` model class helps when linking objects together.¹¹. `PermissionService` class is also injected for use by resource handler classes. `PermissionService` class handles various authorization related functionalities. Authorization related functions include: check if user is admin, check if users can access reports, check if a given user can edit or update database objects, check if a given user owns certain model classes, etc...

Traccar's access control method

Traccar server users belong to different *user roles* which gives them a different set of capabilities in managing other users and objects.

Main user roles:

- *Admin* is a superuser that has full unlimited access to the whole Traccar server.
- *Manager* is a user with extended capabilities allowing him to manage his subset of users and register new ones.
- *User* is an ordinary user that can manipulate any of his own objects and add new ones.

Limited user roles:

- *Readonly user* is a user that cannot add/edit/remove anything in the system. He can only monitor his objects. Can be used for public/embedded access to Traccar.
- *Device readonly user* is an ordinary user with a restriction on device manipulation. Other objects can be edited without limits.

User limits:

- *Device limit* the limit for number of devices that user can have. User cannot add devices more than his device limit.
 - If device limit is set to **-1**, it means that the user has no limit on the number of devices.

¹¹how?

- If device limit is set to **0**, it means cannot add any devices, but he can edit or remove existing ones.
- *User limit* the limit on number of users that manager can have. Manager cannot add users more than his user limit.
 - If user limit is set to **-1**, it means that manager has no limit.
 - If user limit is set to **0**, it means that user is not a manager. The difference between manager and regular user is in their user limit value. Manager has limit not equals to 0.
- Only administrators can change the above two *limit* values. Users created by a manager will always have 0 value for both limits. Newly registered users will have *device limit* set to -1 or value from server config `users.defaultDeviceLimit`.
- *Expiration time* is the time after which user cannot log into the system.
- *Disabled* users cannot log in.
- *User* or *manager* cannot edit the above two values in their own accounts.
- *Manager* can edit these fields for the users he has access to, with one restriction. If *manager* has expiration time, he cannot set other users expiration time later than his own.
- Also, one important restriction is that only *administrator* can unlink devices from himself.

As we have seen above, after the server decodes session login information and extracts the logged in user's ID, it loads the user data stored in the database by finding the matching database row with same `user_id`. The `Server` object stored in the database also has special values for *limits*.

`PermissionService` class performs this operation and it also has convenience function for access control management: `getUser(long userId, ...)`, `checkEdit(long userId, ...)`, `checkAdmin(long userId, ...)` ...

```
select *
from tc_users as u
where u.user_id = user_id_from_session_cookie;
```

The returned user has *access control* properties that are used by the server to determine which resources the user has access to. To illustrate how initial access control works, let us examine how the request `POST /api/drivers` with payload `"name": "Steve McQueen"` would work for a *readonly* user. A *readonly* user is an ordinary user with its `Boolean readonly` set to `true`. After the `userId` in the cookie payload is decoded, the following code listing is run. As we can see from line 50, `getUser(userId).getReadOnly()` sets `denied` to `true` which then is the condition for `throw SecurityException`.

```

1 // Drivers.class, inherited from BaseObjectResource.java
2 @POST
3 public Response add(T entity) throws StorageException {
4     permissionsService.checkEdit(getUserId(), entity, true);
5
6     BaseObjectManager<T> manager = Context.getManager(baseClass);
7     manager.addItem(entity);
8     LogAction.create(getUserId(), entity);
9
10    storage.addPermission(new Permission(User.class, getUserId(), baseClass,
11 ↪ entity.getId()));
12    LogAction.link(getUserId(), User.class, getUserId(), baseClass, entity.getId());
13
14    if (manager instanceof SimpleObjectManager) {
15        ((SimpleObjectManager<T>) manager).refreshUserItems();
16    } else if (baseClass.equals(Group.class) || baseClass.equals(Device.class)) {
17        Context.getPermissionsManager().refreshDeviceAndGroupPermissions();
18        Context.getPermissionsManager().refreshAllExtendedPermissions();
19    }
20    return Response.ok(entity).build();
21 }
22 // PermissionService.java
23
24 public void checkEdit(long userId, Object object, boolean addition) throws
25 ↪ StorageException, SecurityException {
26     if (!getUser(userId).getAdministrator()) {
27         checkEdit(userId, object.getClass(), addition);
28         boolean denied = false;
29         // Only Device and Group classes extend GroupModel.
30         if (object instanceof GroupedModel) {
31             long groupId = ((GroupedModel) object).getGroupId();
32             if (groupId > 0) {
33                 checkPermission(Group.class, userId, groupId);
34             }
35         }
36         if (object instanceof ScheduledModel) {
37             long calendarId = ((ScheduledModel) object).getCalendarId();
38             if (calendarId > 0) {
39                 denied = storage.getPermissions(User.class, userId, Calendar.class,
40 ↪ calendarId).isEmpty();
41             }
42         }
43         if (denied) {
44             throw new SecurityException("Write access denied");
45         }
46     }
47 }
48
49 public void checkEdit(long userId, Class<?> clazz, boolean addition) throws
50 ↪ StorageException, SecurityException {
51     if (!getUser(userId).getAdministrator()) {
52         boolean denied = false;
53         if (getServer().getReadonly() || getUser(userId).getReadonly()) {
54             denied = true;
55         } else if (clazz.equals(Device.class)) {
56             denied = getServer().getDeviceReadonly() ||
57 ↪ getUser(userId).getDeviceReadonly();
58         }
59         if (addition) {
60             int deviceCount = storage.getPermissions(User.class, userId,
61 ↪ Device.class).size();

```

```

56         denied = deviceCount ≥ getUser(userId).getDeviceLimit();
57     }
58     } else if (clazz.equals(Command.class)) {
59         denied = getServer().getLimitCommands() ||
↪ getUser(userId).getLimitCommands();
60     }
61     if (denied) {
62         throw new SecurityException("Write access denied");
63     }
64 }
65 }
66
67

```

From the code listing above in particular line 50, we can see that there exists a layer between the database interfacing `Storage` object and the controller code. `BaseObjectManager` sits between the aforementioned layers acting sort of like a caching. This means incoming payload data is not directly written to the database in the resource handler but it is first written to the “caching” object and then, finally, committed to the database. `PermissionManager` (not to be confused with `PermissionService` we saw above) handles Object linkage access control. Users in traccar server manage other objects depending on the capabilities and limits. For example, an *ordinary user* can access a set of *devices* based on its permission. Traccar follows a sort of Access Control Lists (ACL) method to manage access control permissions. A simple ACL example is given below⁵. Every time we create these objects which need permission to be accessed we add a new entry to the object’s ACL with the user with whose context the object is created with. As we can see from the table below for example⁶, `user_id = 0` can access two devices with `device_id = 0, 1`. The code snippet below adds to the SQL table (represented here as `Permission`) `tc_users_drivers` a single row similar to the rows in table 6. `Permission` objects (ACL tables) are bound on the fly, so there is no class in Traccar like `IpkUserTcUser`. Traccar server literally scans `BaseModel` class for sub-classes:

```

1 public class Permission {
2
3     private static final Map<String, Class<?>> CLASSES = new
↪ TreeMap<>(String.CASE_INSENSITIVE_ORDER);
4
5     static {
6         try {
7             for (Class<?> clazz :
↪ ClassScanner.findSubclasses(BaseModel.class)) {
8                 CLASSES.put(clazz.getSimpleName(), clazz);
9             }
10            } catch (IOException | ReflectiveOperationException |
↪ URISyntaxException e) {
11                throw new RuntimeException(e);
12            }
13        }
14
15        // ... rest of the class.
16    }

```

```

1 storage.addPermission(new Permission(User.class, getUserId(), baseClass,
  ↳ entity.getId()));

```

Device	Access Control List
0	User 0 = read + write, User 1 = read, User 2 = read
1	User 0 = read, User 1 = read + write, User 2 = read + write

Table 5: A sample ACL

device_id	user_id
0	0
1	0
2	1

Table 6: A sample ACL

Our modification to Traccar

Our modification should:

Traccar has a different set of definition for time.

Some devices send two timestamps:

1. Time of the GPS fix (fixTime)
2. Time when the message was formed (deviceTime)

Traccar fronted notes

- EditItemView generic UI.
- ReportFilter generic UI.
- Attributes are extra data that are not specified in the database schema but stored as a blob?

Also, if message from device doesn't contain location data, but have some other valuable information (for example, sensor data), Traccar decodes that data and uses latest known GPS location. That's how you can get different values for `fixTime` and `deviceTime` columns. For queries it's better to use `fixTime` as there is an index for it.

- Reuse as much code as possible.
 - One interesting idea is to simply add firebase user, traccar user mappings.
 - Insert and admin user from firebase auth dashboard.

Web security with CORS

Same Origin Policy (SOP)

Every resource (images, binary data, JSON from API calls, CSS, sounds, ...) loaded by a web browser is assigned an origin tag that is made up of its scheme, domain, and port.

$$O = s + d + p$$

where O is origin, s is scheme ([http](#) or [https](#)), d is the whole domain which includes all subdomain fragments and p is the port. Two or more origins are said to be from the *same origin* if the scheme, domain and port of each origin is the same. Same origin can be thought of as function that takes multiple origins and returns a boolean.

$$SO = f(O_1, O_2, \dots, O_n) \rightarrow Boolean$$

What is important to note is that, the web browser loads content from each origin in its own sandboxed context, and each sandboxed context has no means of accessing a context from another origin. For example in the code snippet shown below, javascript code from [site-one.com](#) cannot access data contained `` tag because it has different origin from the `` tag which is from [site-two.com](#). We can also see that loading webpages into two or more different browser tabs/windows is not the the only of creating different sandboxed contexts.

We should note that however, code loaded in one context can access the data of another context if it has *handle* to the second context. One way to obtain that handle is to create the context we want to access with `window.open` function.

```
|| // this javascript is run from the context of site-one.com
|| // now handle can read and write the data (js + dom) of context two.
|| let handle = window.open("https://site-two.com", "right");

|<!-- webpage loaded from https://site-one.com -->
|
|<!-- note that we can not read data from the style sheet but
|      stylesheet
|      applies to the page. -->
|<link rel="stylesheet" href="https://bootstrap.com/style.css" />
|<div>
|  
|  <!-- rest of site-one.com -->
|</div>
```

Although static resources in one origin's context cannot be read from another origin's context, javascript loaded from another origin can actually read and modify the data of the loading context even though they don't have the same origin because it is loaded into the same context as that of loading origin's. This flaw that still exists because of legacy compatibility reasons combined with the fact that any javascript that is from the same origin can access cookie jars that are by definition global to the origin is reason for Cross Origin Request Forgery (CSRF) exploits⁸.

SOP and Cookies

- cookies used to persistent session data, like logged in user info of a shopping site.
- logged in users can order items from the shopping site.
- cookie jar as global map of ...

Browser cookies are browser global objects that store site related data. The server sets a cookie *value* using the `Set-Cookie: cookieName=cookieValue` HTTP response header. The browser then set the cookie for that specific domain in the cookie jar. Next time the web browser sends request to the server it attaches the cookie in the HTTP header like `Cookie: cookieName=cookieValue`. Cookie jars are different from origin specific origins in that cookies are global and not session based. Every time a user makes a request to a server the hostname is matched against cookie domain value stored in in the cookies jar and if it is found the cookie values are attached to request and sendt to the server. Since cookies are not session specific they are used to persist HTTP request which are stateless by their nature. For example, without the use of cookies the browser needs to send authentication (for example username, password combo) on every request. but with cookies we can mark a user as authenticated by setting the cookie with value like `loggedIn=true, userId=0001` and on the subsequet request the user will send this info with the request. the server then can know the user is logged in.

Since values in the cookie are not attached to the first origin that requested them and can be attached to any request whose destination the same as the cookies domain value, it is very easy to impersonate a user with an elevated privilege. For example, consider this scenario: A user is authenticated on a shopping website and this fact is stored in the cookie store. what if an attacking website persuades the user to make this request from hostile website?

```
<form method="POST" action="http://shoppingsite.com/make-order">
<!--
    cart = ["PS5", "Scooter", "TV set"],
    destination = "attackers address"
-->
</form>
```

the from request url is matched against a domain key in the cookie jar and the request is sent with the cookie values loaded. but remember the the request is from a non authenticated context.

Cross-Origin Request Sharing (CORS)

As we have seen above, the browsers strict SOP enforcement means we can not, for example, read data from api calls of different origin because the data is loaded into a separate context. This limitations seriously constrains the usefullness of web platform since so much of useful functionality is provided by third party API servers. CORS allows weakening of SOP so that data can be loaded from different origin. Request from the context of site-one.com makes `XMLHttpRequest` to site-two.com, but since the data coming

of site-two.com is coming from different origin site-one.com cannot read it. CORS works as follows:

1. code from site-a.com's context makes an `OPTION` (no payload) request to site-b.com with the HTTP header `Origin` specifying the origin (scheme, domain, and port) of the request.
2. The server sees this and responds with header only response with response including `Access-Control-Allow-Origin: * | origin`
3. When the browsers sees a response with appropriate `Access-Control-Allow-Origin` it allows the loading of resource into site-a's context.

By default, CORS request are anonymous, i.e., a cookie data is not attached with the request. Of course, we can bypass this. A CORS request javascript side is made as follows:

```
// in the options object, "mode" must be set to "cors" to make CORS
// requests.
// by setting "credentials" to "include" we instruct the browser to
// send cookie data
// with the request.
let resp = await fetch("https://site-b.com", {
  mode: "cors",
  credentials: "include",
});

let data = await resp.json();

// If the CORS request is successfull, data can be read from.

/*
  Request timeline

  -> Origin: https://site-a.com

  ---

  <- Access-Control-Allow-Origin: * | https://site-a.com
  <- Access-Control-Allow-Credentials: true
*/
```

The ability of web clients to load a 3rd party and potentially adversarial javascript code which can make AJAX calls to our server with an authenticated user context presents us with a potential security vulnerability. To mitigate this, we can instruct the web browser to attach the *origin* of each AJAX call.

Origin of a web request tells us from which javascript code each request originates from. Origin is scheme, domain, port. Normally, the web browser creates separate context for each web page window. each window cannot snoop on each others data. but can a 3rd party javascript access loaded from a webpage access its internal data? and if it does what is the security implication. we can actually see the contents of another window if have handle (js reference) to that window. sandbox. same origin as a function that takes origins and returns boolean. different classes of resources: js, css, img, cookies etc... cookies are global not session based... which leads to CSRF. Secure; HTTP-ONLY;... CORS allows a site to 'opt-in' to weakening SOP and allow other sites to read data.

URL A	URL B	Same origin?
http://goodsite.com/a	http://goodsite.com/b	Yes
http://goodsite.com	https://goodsite.com	No (different scheme)
http://goodsite.com/	http://www.goodsite.com	No (different domain)
http://goodsite.com	http://goodsite.com:8080	No (different port)
http://goodsite.com/user	http://goodsite.com/admin	Yes

Table 7: Web origin examples

SQL notes

Why did relational databases win out? Database is a *set* of related information¹². Databases can be indexed with some *key*. A phonebook has letters on its margins. We can use the letters on the margins to find phonenumbers quicker. We call this process *indexing*. relational mode of data storage is the most commonly used. heirarchial mode of data storage was more popular in the past. in heirarchial data storage scheme data is stored in a tree fasion. as an example of heirarchial data storage we can consider the case of bank account storage.

network based database store records with pointers to other records. user can extract data by traversing the linking pointers. relational database is the most common now. primary keys uniquely identify a row in relational table. primary keys need not be generated by the database management software. several columns can generate a unique key for each row. *fname* and *lname* in the database attached can be used as a primary key. primary keys made out of multiple columns are called *compound key*. *natural keys* are keys generated from the data itself. *surrogate keys* are keys appended by the database designer. database designers generate surrogate primary keys because no natural key can be used to identify a row. primary keys should never change once they are assigned. relational database tables include column whose value point to entries in other tables. column value that point to another table are called foreign keys. foreign keys perform the same function as pointers in network based database systems. the process of “lensing” into foreign key of table is called a *join operation*. storing redundant is not considered a problem in relational database system. we must be sure that redundant data stored has a reason to be redundant. canonical data should be stored in one table. foreign keys (pointers) can be redundant. duplication of canonical data causes for unreliable data. a single column should just include one data. this process of making canonical data non redundant, storing single values in each column is called *normalization*. sql is a computer language that was specifically designed to manipulate relational databases. Edgar F. Todd described relational database systems. he proposed a language called DSL/Alpha for relational database systems. IBM created a language called SQUARE by refining edgar f. codds language. SQUARE was refined to SEQUEL. SEQUEL was shorted to SQL. The result of sql query is a table. a new table can be created in sql by simple storing the result set of an sql query. a query can use both permanent tables and result set of another query. sql is not an acronym for anything. sql is short

¹²Learning SQL

for sequel. sql is a non procedural computer language. we do not tell the sql engine how to retrieve our data. we describe the data we want to the sql engine and the sql engine retrieves the data the most efficient way possible. sql statement types can be divided into three types. *schema statements* are used to define data structures stored in the database. *data statements* are used to manipulate data structures created by schema statements. transaction statements are used to begin, end, and rollback transactions. an example of a the schema statement `create table`:

- temporal data types. - constraints, especially foreign ones. - table joins.

```
|| create table corporation (corpid smallint, name varchar(30),
||     constraint pk_corporation primary key (corp_id));
```

the above statement creates a table with two columns. the tables names is corporation. `corp_id` is identified as the primary key. primary keys are a type of constraint. `insert` is a data statement that is used to insert a row of data into a table. notice the single quote in insert.

```
|| insert into corporation (corpid, name) values (30, 'SpaceX');
```

another data statement is `select` statement. `select` statement is used to extract data from the database.

```
|| select (name, corp_id) from corporation where corp_id=30;
```

all database elements created with sql schema statements are stored in a set of special tables called *the data dictionary*. this set of metadata tables can be queried just like other sql tables.

several *clauses* make up a query statement. only `select` is mandatory for a query statement. `select` clause runs last after filtering, grouping and ordering operations. instead of just *selecting* rows from operation of other clauses, for example `from` clause's, `select` clause can add synthetic rows to the result set. we can think of like the other clauses providing `select` for columns to select from. `as` introduces a column alias. `from` clause defines the tables used by a query, along with the means of linking tables together. `from` clauses are very important for table join operations.

```
-- select every column from language table for the result set.
select * from language;

-- select just language_id and name from language table for the
result set.
select language_id, name from language;

-- select for 'synthetic' rows.
select
    language_id as id, -- id is a column alias for language_id
    'COMMON' as language_usage, -- 'synthetic' row
    language_id * 3.1415927 as lang_pi_value, -- 'synthetic' row
    upper(name) as language_name, -- 'synthetic' row
    version() as version -- or even this!
from
    language;
```

`from` clause can take various forms of tables:

1. *Permanent tables* created with `create table`.

2. *Derived tables* returned from a subquery and held in memory.
3. *Temporary tables* that are volatile tables held in memory.
4. *Virtual tables* created with `create view` statement.

```

select
    concat(cust.last_name, ', ', cust.first_name) as full_name
from -- from clause taking in a derived table.
    (select
        first_name,
        last_name,
        email
    from
        customer as c
    where
        c.first_name = 'JESSIE') as cust;

```

Clause name	Purpose
<code>select</code>	Determines which query to include in the query's result set
<code>from</code>	Identifies the tables from which to retrieve data and how the tables should be joined
<code>where</code>	Filters out unwanted data
<code>group by</code>	User to group rows together by common column values
<code>having</code>	Filters out unwanted groups
<code>order by</code>	Sorts the rows of the final result set by one or more columns

Table 8: Query clauses

`from` clauses can also choose from 2 or more tables. by default from statement with out a join type will perform cross product for each row of all the columns of table A with all columns of table B. table joins can be chained together for more than two tables.

```

select
    concat(cu.first_name, ' ', cu.last_name) as name, ct.city
from
    customer as cu
    inner join address as ad
        on cu.address_id = ad.address_id
    inner join city as ct
        on ad.city_id = ct.city_id;

```

one unique customer (by definition) can have multiple rental records. this, we call one-to-many relationship.

`group by` collects rows by equality of rows we provide. `count(column)` stores how many there are in a group.

```

select
    f.film_id, f.title, count(*) num_copies

```

```

from
    film as f
    inner join inventory as i
        on f.film_id = i.film_id
group by
    f.film_id, f.title;

```

inner join truncates rows that are not in both tables based on the condition we provided. to include rows of one table no matter what, we employ **outer join**.

```

select
    -- note: count(i.inventory_id)
    f.film_id, f.title, count(i.inventory_id) num_copies
from
    film as f
    left outer join inventory as i
        on f.film_id = i.film_id
group by f.film_id, f.title
order by f.film_id;

```

PostgreSQL

PostgreSQL is one of the most popular sql based database management systems. PostgreSQL is fully opensource. PostgreSQL is developed by Berkley University. installing postgresql on an Arch Linux machine creates a **postgres** user. **postgres** user is the only one allowed to interact with the database system. to change to user postgres use the following command. command work if **sudo** is installed. postgresql follows the client server model. postgresql server manages the datastore. postgresql server receives sql commands from clients and executes it against the datastore. servers and clients need not be on the same host. server client can communicate using TCP/IP.

```

sudo -iu postgres

```

then while we are user **postgres**, initialize the database cluster with locale and encoding we desire.

```

# initializes a database cluster.
# run as `postgres` unix user.
initdb --locale=en_US.utf8 --encoding=UTF8 \
    -D /var/lib/postgres/data --data-checksums

```

PostgreSQL installs the following programs on our system: **psql** is a postgresql client that helps us interact with PostgreSQL from a terminal session. **createuser** is used to create PostgreSQL roles. **postgres** is used to manage the server process. **initdb** is used to initialize database clusters. **createdb** to create new database (not a cluster). **dropdb** to remove a database. commands from postgresql package must be run from the **postgres** unix user. postgresql has the concept of roles. roles in postgresql are a username password combo that is used to connect with a specific database. unix users and postgresql roles are a completely different concepts. a database client from a remote machine can use a database installed locally by providing the correct roles. management of the database server is performed by **unix** user **postgres**. postgresql comes with one default role

postgres. postgres role is a super user role. super user roles can read and write to every database. super user roles can create and drop roles. linux user postgres and postgresql superuser role having the same name make things a little confusing. postgresql roles can be create from the terminal using createuser or from the interactive sql shell psql using sql statement: we can connect to to database using superuser role postgres from anywhere!

```
|| create role dbname;
```

postgresql db roles can be removed using:

```
|| drop role dbname;
```

Create a database for role dbname.

```
|| # create database named db for role dbname
|| # remember unix user is postgres
|| createdb db -O dbname
```

Then connect to the database using psql

```
|| psql db -U dbname
```

we will be presented with the following prompt.

```
|| psql (14.3)
|| Type "help" for help.
||
|| db=>
```

arrow instead of hash in db=> indicates we are a non superuser role. contrast this with prompt for superuser role postgres:

```
|| psql (14.3)
|| Type "help" for help.
||
|| db=#
```

we can use psql command \dt+ to list all available tables in a database.

Algorithms

What are algorithms?

An *algorithm* is is any well defined computational procedure that takes some value, as *input* and produces some value, or a set of values, as *output* in finite amount of time. Essentially algorithms are a set of procedures that transform input to outputs.¹³

Alternatively an algorithm can be described as a tool for solving a well defined *computational problems*. The statement of problem describes the desired input/output mapping for problem instances. The algorithm describes computational procedures for achieving the desired input/output relationship for all problem instances.

Example problem: sort a sequence of numbers in ascending order. Below is how we formally define *the sorting problem*.

Input: A sequence of n numbers $\langle a_1, a_2, \dots, a_n \rangle$.

Output: A permutation (reordering) $\langle a'_1, a'_2, \dots, a'_n \rangle$ of the input such that $a'_1 \leq a'_2 \leq \dots \leq a'_n$.

¹³As defined in the Algorithms book.

- a correct algorithm should produce the correct output for each input but also halt. (finite running time.)
 1. Prove that the algorithm actually *works*.
 2. Analyze the running cost of the algorithm especially in terms of order of growth.
- The example of comparison between a slow implementation of merge sort with cost of $c_1 n \lg n$ and insertion sort with running cost of $c_2 n^2$ is illuminating.

C++ notes.

Smart pointers.

I should avoid using raw pointers whenever possible. Why?

- Declaration does not indicate whether they point to a single object or an array.
- Declaration does not tell us whether a pointer should destroy the object it is pointing at i.e. it is owning.
- There is almost no way to know whether to call `delete` or `delete []` from its declaration.
- Pass the pointer to a dedicated destroy function or just `delete` it? Hard to know.
- `std::unique_ptr<T>` encapsulates the single ownership concept.
- `unique_ptr` is the only creator and destroyer of an object.
- `std::shared_ptr<T>` described using people in a hall last one turns off the lights analogy. how?

```
#include <memory>
#include <iostream>

using std::cout, std::endl;
using UniquePtrInt = std::unique_ptr<int>;

void takesUptr(UniquePtrInt uptr) {
    cout << "*uptr = " << *uptr << endl;
}

int main() {
    UniquePtrInt p { new int {30}};

    takesUptr(std::move(p));

    // p is nullptr
    // p has been "moved" from, so it is invalid.
    if(p)
```

```

    cout << "*p = " << *p << endl;
    return 0;
}

```

RAII

- Always prefer list initializations.
- Member declaration site initializations run before constructors.
- Constructor overloading is good.
- Constructors can `throw` exceptions and infact it is preferred to do so to “preserve” the class invariant.

Profiling and (micro)benchmarking

The real problem is that programmers have spent to much time worrying about efficiency in the wrong places and at the wrong times.¹⁴

1. Sampling profiling.
2. Instrumentation profiling.

And for benchmarking

1. Micro benchmarking
2. Macro benchmarking

imporatant <https://youtu.be/fHNmRkzxHws?t=2122>

Algorithms

$$a = a + b$$

¹⁴Mathieu Ropert—youtube video

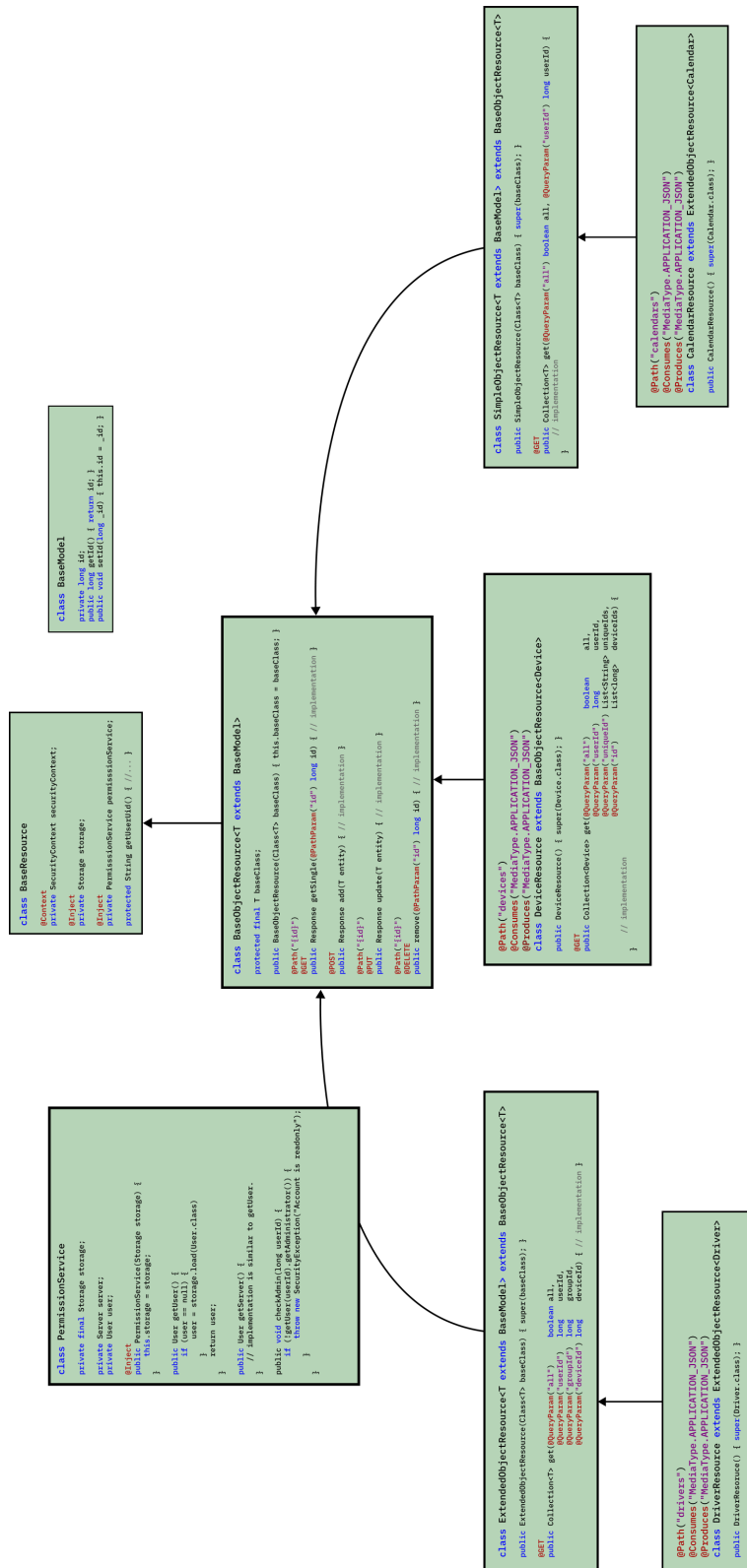


Figure 7: Traccar UML chart

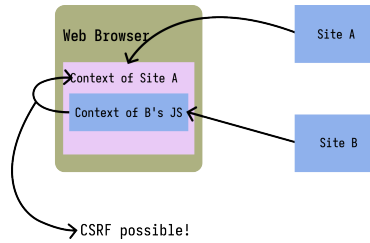


Figure 8: SOP and Javascript

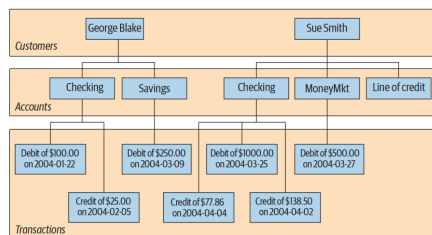


Figure 9: Heirarchial mode of data storage.

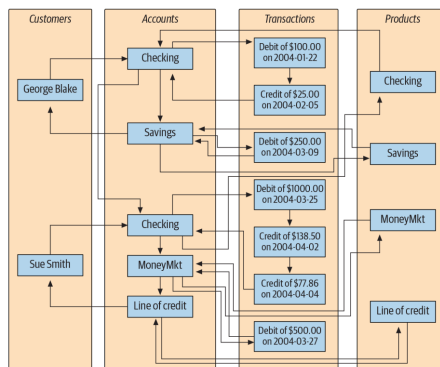


Figure 10: Heirarchial mode of data storage.

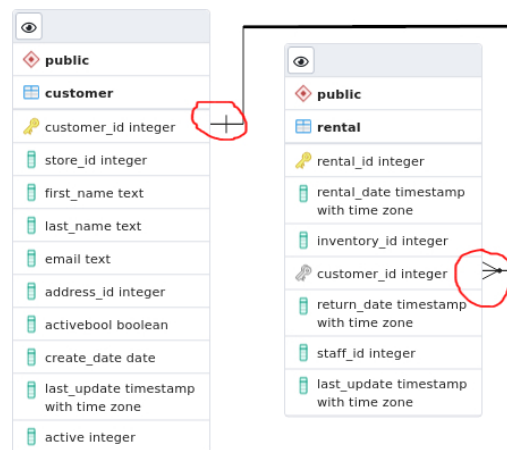


Figure 11: One to many relationship in tables