4 ALLOY

We have done this model referring to the Class Diagram. The file taxi.axl can be found on our repository (https://github.com/MassimoSchiavo/MyTaxiService-Schiavo-Cittar) . We have divided signature, fact, assertion and predicate. In the last part there is the metamodel created with alloy analyzer and a world created with the predicate show.

4.1.1 SIGNATURE:

```
sig Integer{}
sig Strings{}
enum Boolean{YES,NO}

sig TaxiQueue{
        locations: set Location,
        drivers:set Driver}

sig Driver{
        available:one Boolean,
        taxi:one Taxi,
        confirmedRequest: set Request}

sig User{
        requests: set Request}

sig Time{
        hour:one Integer,
        minute:one Integer}

sig Date{
        day:one Integer,
        month:one Integer,
        year:one Integer}

sig Taxi{
        code:one Integer,
        actualPosition:one Location,
}

sig Location{
        address:one Strings,
        civicNumber:one Integer}

sig Notification{
        message: one Strings,
        user:one User,
        request:one Request}
```

4.1.2.ABSTRACT SIGNATURE

```
abstract sig Request{
        id:one Integer,
        confirmed:one Boolean,
        startLocation:one Location}
```

4.1.3 IMPLEMENTATION OF ABSTRACT SIGNATURE

```
sig SimpleRequest extends Request{}

sig DetailedRequest extends Request{
        endLocation:one Location,
        date:one Date,
        time:one Time}
```

4.1.4 FACT: This is the fact part that defines the costraint of the class.

```
fact noEmptyDate{
        all d:Date|(#d.day=1)and(#d.month=1)and(#d.year=1)
}

fact noEmpyTime{
        all t:Time|(#t.hour=1) and (#t.minute=1)
}

fact noEmptyDriver{
        all d:Driver|(#d.taxi=1)
}

fact noEmptyTaxi{
        all t:Taxi|(#t.code=1) and (#t.actualPosition =1)
}

fact noEmptyRequest{
        all r:Request|(#r.id=1) and (#r.startLocation=1) and (#r.confirmed=1)
}

fact noEmptyDetailedRequest{
                all rd:DetailedRequest|(#rd.endLocation=1) and (#rd.date=1) and (#rd.time=1)
}

fact noEmptyLocation{
        all l:Location|(#l.address=1) and (#l.civicNumber=1)
}

fact noEmptyTaxiQueue{
        all tq:TaxiQueue|(#tq.locations>0)
}
```

```
//Every location is insert into one and only one TaxiQueue and a TaxiQueue is formed at least by one location
fact noDuplicatedTaxiQueue{
	all l:Location|no disj tq1,tq2:TaxiQueue|(l in tq1.locations) and (l in tq2.locations)
	all l:Location{some tx:TaxiQueue|l in tx.locations}
}

//Every taxi has only one driver and any driver drives only one taxi
fact oneDriverOneTaxi{
	all d:Driver|no disj t1,t2:Taxi|(t1 =d.taxi) and (t2 = d.taxi)
	all t:Taxi|no disj d1,d2:Driver| (t =d1.taxi) and (t = d2.taxi)
}

//Every request is unique and exits only if a user has done it
fact noDuplicatedRequest{
	no disj r1,r2:Request|r1.id=r2.id
	all r:Request|no disj u1,u2:User|(r in u1.requests) and (r in u2.requests)
	all r:Request|one u:User| r in u.requests
}

//Every Taxi has different code between each other
fact noDuplicatedTaxi{
	no disj t1,t2:Taxi|t1.code=t2.code
}

//All drivers available are isert into a queue in corrispondance of his taxi's location
//Drivers not available are not into a Taxi Queue
fact avaiableToQueue{
	all d:Driver|d.available=YES => {one tq:TaxiQueue|(d in tq.drivers) and (d.taxi.actualPosition in tq.locations)}
	all d:Driver|d.available=NO => {all tq:TaxiQueue|(d not in tq.drivers)}
}

//A notification exist only if the notified has done a request that has already been accepted
fact notify{
	all n:Notification|one u:User|(u = n.user) and{one r:Request|(r in n.request) and (r in u.requests) and (r.confirmed=YES)}
	all r:Request|(r.confirmed=YES)=>one u:User|r in u.requests and{one n:Notification|(n.user=u) and (n.request=r)}
}

//StartLocation and endLocation of a detailed request must be two different place
fact diffLocation{
	all dt:DetailedRequest|dt.startLocation!=dt.endLocation
}
```

```
//Two Taxi Queue with a shared driver must not exist
fact oneQueuePerDriver{
        all d:Driver|no disj tq1,tq2:TaxiQueue|(d in tq1.drivers) and (d in tq2.drivers)
}

//driver can accept request only if are in taxiqueue in which the startLocation is included
fact Acceptance{
        all r:Request|r.confirmed=YES <=> {one tq:TaxiQueue|(r.startLocation in tq.locations)and{one
d:Driver|(d in tq.drivers) and(r in d.confirmedRequest)}}
        all r:Request|r.confirmed=NO <=> {one tq:TaxiQueue|(r.startLocation in tq.locations)and{all
d:Driver|(d in tq.drivers) and (r not in d.confirmedRequest)}}
        all r:Request|no disj d1,d2:Driver|(r in d1.confirmedRequest) and (r in d2.confirmedRequest)
}
```

4.1.5 ASSERTION These are the asserts used to verify the model.

```
//Every location can't be insert into two different taxis queues
assert LocationInoneTaxiQueue{
        all l:Location|no disj tq1,tq2:TaxiQueue|(l in tq1.locations) and (l in tq2.locations)
}
check LocationInoneTaxiQueue for 10

//Once a request is confirmed by a driver it cannot be confirmed by anyone anymore
assert RequestsConfirmedByOnlyOneDriver{
        all d1,d2:Driver|no r:Request|(d1!=d2) and (r in d1.confirmedRequest) and (r in
d2.confirmedRequest)
}
check  RequestsConfirmedByOnlyOneDriver for 10

//Every request is unique and belongs to only one user
assert oneOwner{
        all u1,u2:User|no r:Request|(u1!=u2) and (r in u1.requests) and (r in u2.requests)
}
check oneOwner for 10

//Verify acceptance fact.
assert Acceptance{
        all sr:SimpleRequest|lone d:Driver|(sr.confirmed=YES) and (sr in d.confirmedRequest)
        all r:Request|no d:Driver|(r.confirmed=NO) and (r in d.confirmedRequest)
        all r:Request|r.confirmed=YES implies one tq:TaxiQueue|(r.startLocation in tq.locations) and {one
d:Driver|(d in tq.drivers) and (r in d.confirmedRequest) and (d.taxi.actualPosition in tq.locations)}
}
check Acceptance for 5

//Verify Notification fact.
assert Notification{
        no n:Notification|n.request.confirmed=NO and n.user=none
}
check Notification for 6

//Verify available to Queue
assert availableToQueue{
        all tq:TaxiQueue|no d:Driver|(d in tq.drivers) and (d.available=NO)
        all tq:TaxiQueue|all d:Driver|(d in tq.drivers)=>(d.available=YES)
}
check availableToQueue for 6

//Verify DiffLocation fact.
assert DiffLocation{
        all dt:DetailedRequest|no l:Location|dt.startLocation=l and dt.endLocation=l
}
check DiffLocation for 6
```

```
//Verify beAvailable pred.
assert beAvailable{
        all d:Driver|(d.available=NO) and beAvailable[d] implies (d.available=YES)
}
check beAvailable for 6

//Verify accept pred.
assert accept{
        all d1,d2:Driver|all r:Request| ((d1=d2) and(d1.available=YES) and (r.confirmed=NO) and
accept[d1,d2,r])implies((r in d2.confirmedRequest) and d2.available=NO and r.confirmed=YES)
}
check accept for 6
```

4.1.6 PREDICATES These are the predicates used with the previous assert to verify the model.

```
pred beAvailable(d:Driver){
        (d.available=NO) implies (d.available=d.available - NO + YES)
}
run beAvailable for 6

pred accept(d1,d2:Driver,r:Request){
        (r not in d1.confirmedRequest and d1.available=YES and d1=d2) implies
(d2.confirmedRequest=d1.confirmedRequest+r and r.confirmed=YES and d2.available=d1.available-YES+NO
)
}
run accept for 4

pred addSimpleRequest(u1,u2:User,sr:SimpleRequest){
        (sr not in u1.requests) implies (u2.requests=u1.requests+sr)
}
run addSimpleRequest for 4

pred addDetailedRequest(u1,u2:User,dt:DetailedRequest){
        (dt not in u1.requests) implies (u2.requests=u1.requests+dt)
}
run addDetailedRequest for 4

pred show(){
        #TaxiQueue>1
        #User>1
        #Driver>1
        #Taxi>1
        #Request>1
        #Location>1
}
run show for 4
```

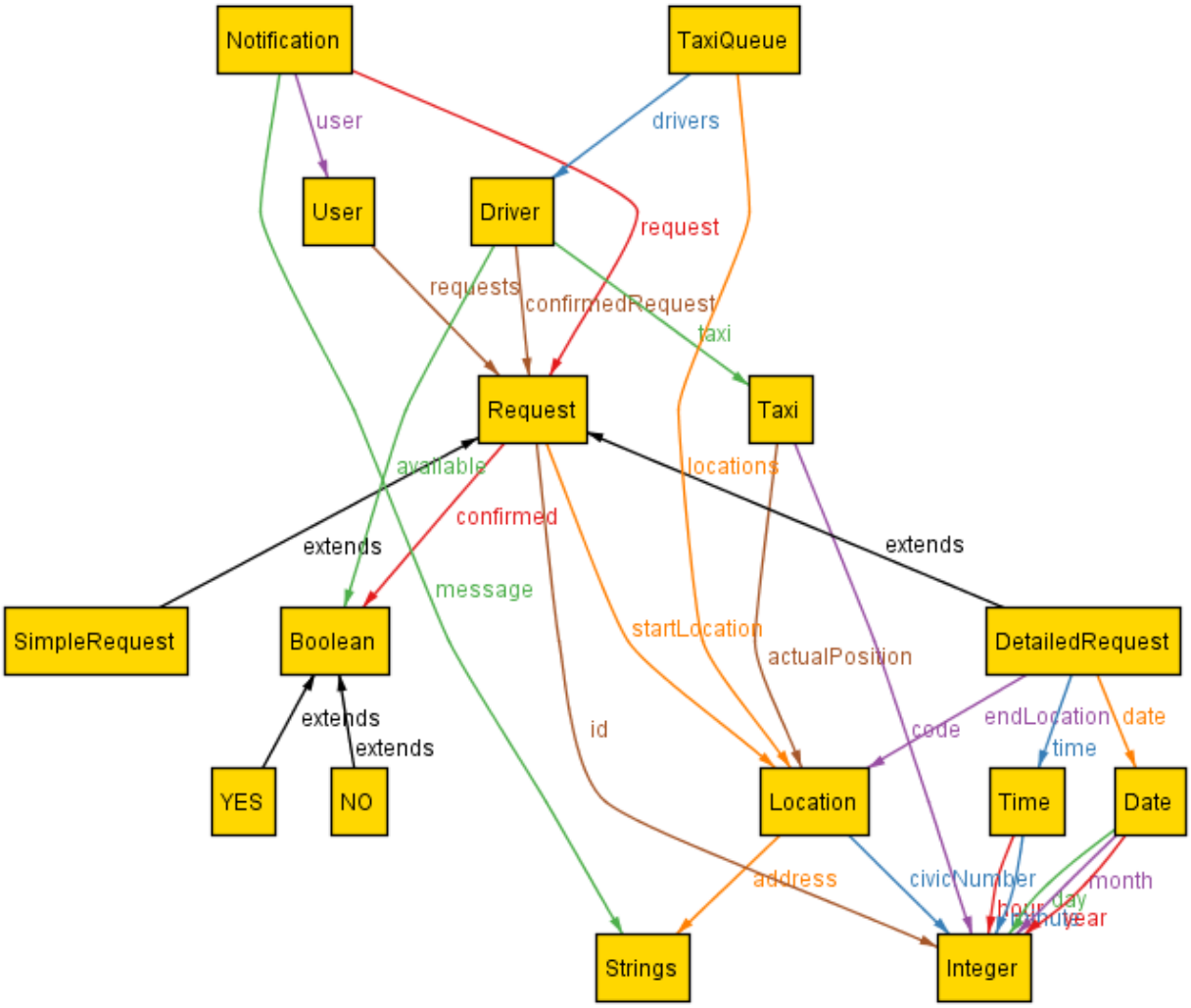
4.1.7 RESULTS and METAMODEL

Results obtained with the alloy analyzer that show the consistency of the model in all parts.

14 commands were executed. The results are:

#1: No counterexample found. LocationInOneTaxiQueue may be valid.
#2: No counterexample found. RequestsConfirmedByOnlyOneDriver may be valid.
#3: No counterexample found. oneOwner may be valid.
#4: No counterexample found. Acceptance may be valid.
#5: No counterexample found. Notification may be valid.
#6: No counterexample found. availableToQueue may be valid.
#7: No counterexample found. DiffLocation may be valid.
#8: No counterexample found. beAvailable may be valid.
#9: No counterexample found. accept may be valid.
#10: **Instance found.** beAvailable is consistent.
#11: **Instance found.** accept is consistent.
#12: **Instance found.** addSimpleRequest is consistent.
#13: **Instance found.** addDetailedRequest is consistent.
#14: **Instance found.** show is consistent.

A screenshot that represents the metamodel created.



4.1.8 Generated world

The first screeshot represent the world generated with the alloy analyzer using the predicate show() for 2 case. The second using the predicate show() for 2 case with exactly five Location. The third instead using show for 4 case with exactly two SimpleRequest and nine Location. With more cases the scheme would become impossible to read and understand for the presence of too many arrows so we decided not to put more cases in this document.