ARISTOTLE
UNIVERSITY OF
THESSALONIKI

Electrical Engineering & Computer Science

Forensics Database

Crime Scenes

Authors:
Konstantinos Petridis
Xhulio Luli
Ioannis Tatsoglou

Contacts:
kpetridis@ece.auth.gr
tzouliol@ece.auth.gr
ioantats@ece.auth.gr

Team Code: 01

Nov 2021

Contents

1 Introduction

This report is a detailed description of our idea about a Forensics Database, in the context of the related subject. Specifically we are going to construct a **Crime Database**, containing all the necessary data that is relevant to each crime.

1.1 Purpose

It is a non-negotiable fact that the criminality rates are increasing exponentially. This makes the classification of each crime and offender, the practical handling of the information surrounding each scene and the ability to come to conclusions via observation and comparisons of incidents, extremely critical abilities. A direct way to enhance the weapons that we acquire against the criminals, could be the optimization of Databases and their functionalities, which can dramatically assist in analyzing, keeping track of and associating criminal scenes.

1.2 Description

The Database will store for each **crime**, the **perpetrators**, the **victims**, the **evidence** gathered, **weapons** used, the **criminal records** of those involved, the **Investigators** responsible and much more data, relevant to each of the above-mentioned entities. In our initial thought, the available **users** are going to be:

- **regular citizens**, with minimum capabilities, including criminal records and general percentages for each area and time period.
- **police officers** with more authorization but still, limited access.
- **medical examiners**, with capabilities regarding genetic analysis and storage of medical results.
- **lawyers** with bigger usage capabilities, and access to all details.
- **investigators** of each crime with almost full allowance to use the database and its functionalities.
- **administrator** has full access to the database.

In addition, we will try to develop methods, related to the detection of similar patterns between criminal scenes and the comparison of obtained samples to arrive at conclusions.

1.3 Space/Data Requirements

The Space requirements for a Forensics Database cannot be accurately approximated, as the number of daily crimes is mostly arbitrary. However, based on existing global crime statistics, crime rate ranges anywhere between $10 - 90$, which means that, 10 crimes occur in every 100.000 civilians in the low end of the spectrum, and 90 in the high end respectively. In Greece, $150 - 180$ homicides occur per year. However there are many more types of crimes committed, so we cannot define the space required for the application. U.S has counted a total number of 2400 crimes per 100.000 population (including both violent and property crimes). Considering this an expected value, for Greece's population of 11 million, we could estimate the number of crimes to reach 270.000 per year. This comes down to $700 - 800$ Database entries per day.

2 User Categories

In this paragraph we list all the categories of **users**, that have access to the Database. The listing is sorted based on the level of authorization-allowance granted to each user, starting from the most limited user.

2.1 Citizens

Regular citizens have the minimum amount of possibilities when it comes to utilizing the Database. Their abilities are limited to general information obtaining, specifically:

- statistical analysis for the crime rates in each area
- superficial information about criminals and victims

2.2 Police Officers

The police officers are allowed to use the Database in a greater extent. In particular:

- they have access to the actual crimes
- they are 'read-only' users that cannot modify any data
- they are authorized to see some information regarding each scene, but not all of it (for example DNA samples and suspects).
- They only have access to crimes that are solved and the perpetrator has been identified

2.3 Medical Examiners

The Medical Examiner participating in the resolving of each crime , should be able to:

- add the results of DNA analysis
- store the medical report (e.g. cause of death)

His capabilities however should only concern medical topics. The rest of the data for the crime should be restricted for him as well.

2.4 Lawyers

Authorized lawyers, such as the criminal defenders, must have total 'read-only' access to the crime scene's data. This happens because in order to actually be able to defend someone effectively, they have to gather as much information as possible, including every single detail.

2.5 Investigators

An investigator has almost full access to the Database:

- total 'read-write' access, except for the genetic material and the medical analysis.
- authorized to see all the details about the scene
- able to add and modify information regarding victims, offenders, evidence found etc.

2.6 Administrator

An administrator has full access to the database.

3 Entity-Relationship Model

In this section, we briefly describe the entities utilized by the Database, as well as the relation corresponding to each pair of entities. We also mention some assumptions-conventions, that are necessary to create the Database and make it functional, according to the followed design .

3.1 Description

The main entity of the Database, is the **Crime**. Each Crime includes a **Weapon**. The applying relation for the Crime-Weapon is $M : N$, as a crime can include more than one weapon, but it is possible that the same weapon has been used in many crimes as well. Also, there is a number of **Investigators** responsible for the crime's investigation. For this, we assign a $M : N$ relation. Next, the **Offender** is the committer of the Crime. Given that, each offender may have committed multiple crimes and each crime might involve more than one offender, we assign a $M : N$ relation. It should be mentioned here that, there is also a $1 : N$ relation correlating the Offender and the Weapon. In addition, each Offender has been convicted of some sentences during his lifetime. The purpose of the entity **Sentence** is to form each perpetrator's criminal record. The Offender is linked with the Sentence via a $1 : N$ relation because, apart from the fact that a person may have been given a lot of penalties, each sentence is uniquely identified by the id of the assignee. Moving on, every Crime involves a **Victim**. The recommended relation between Crime and Victim is $1 : N$. Lastly, the **Evidence** left behind by each Crime was decided to follow a $1 : N$ relation for obvious reasons. The existing **assumptions** in our current design version are:

- It has not been taken into account the fact that, a **Victim** may have been involved in multiple crimes, thus the $1 : N$ relation.
- The **Victim** may also have a criminal record, but we only assign this feature to the **Offender**.
- The same **Weapon** cannot have been used by multiple offenders.
- Referring to the **Evidence**, there is no already-existing unique key. The uniqueness of each piece of evidence is imposed by the ID of the specific crime, in which the evidence was collected.

- The **Crime-Weapon-Offender** closed loop was considered necessary, because in a crime with multiple offenders involved, each possessing a weapon, there must be a separation between someone who is just armed and someone who actually proceeded to use a weapon causing harm. This critical information is provided by the Weapon-Offender relation. The Crime-Weapon direct relation is also required, since it provides the knowledge of whether the same weapon has been used in more than one crime.

- The Weapon has total participation in the Crime-Weapon relation, because if a weapon is stored in the database, it's obvious that a crime has occurred first.

- The variables of crime entity associated with an area can be NULL. Although it's highly likely that a crime happened in an Area, there is a possibility that the crime is something more widespread, like an online crime, which happens on the internet.

- While logically a weapon involved in a crime cannot exist without an offender possessing it, we assign a total participation to it in relation to the offender. That's because in the Database, the weapon might have been found but the offender remains unknown so the corresponding array is empty.

- A sentence, in general manner, is independent of some offender, but in the Database, we consider each sentence to be unique (using the offender id as key), so we assign a total participation to it, in relation to the Offender.

- It is a fact that, there is no possibility for a crime to occur without the existence of an offender. However, once again we consider that although a crime exists, the offender might not have been identified yet, or may not be ever identified. So the participation of the Crime is partial here.

- it has been decided that a victim cannot exist without the existence of a Crime.

3.2 Entities

Name	Crime
Description	The basic entity of the Database, that stores crimes.
Properties	Strong entity (will exist independently of the other entities)
Attributes	- ID - type - isSolved - date

Name	Weapon
Description	Represents the weapon that was used to commit the crime.
Properties	strong entity (independent of the other entities it will exist)
Attributes	- serialNumber - kind - name - manufacturer - ammunition

Name	Investigator
Description	The assigned investigator for the crime.
Properties	strong entity (will exist independently of the other entities)
Attributes	- idCardNumber - type - name - surname - nationality - credential

Name	Evidence
Description	Represents a specific piece of evidence that was found in the crime.
Properties	weak entity (it cannot exist without the existence of the crime entity)
Attributes	- type - classification - description

Name	Victim
Description	Represents a specific victim in the crime.
Properties	strong entity (independent existence)
Attributes	- name - surname - nationality - injuries - age - job - idCardNumber

Name	Offender
Description	Represents one perpetrator involved in the crime.
Properties	strong entity (independent existence)
Attributes	- idCardNumber - age - height - job - nationality - name - surname - isIdentified - isCaught

Name	Sentence
Description	Represents the criminal record of the perpetrator.
Properties	weak entity (Uniqueness, imposed by the offender id)
Attributes	- penalty - type - date - classification

3.3 Relations

Name of relationship	included
Description	Each crime may contain one or more weapons.
Properties	has-A
Ratio	N:M
Participation	Crime: partial participation Weapon: total participation
Attributes	- crime.Id - weapon.serialNumber

Name of relationship	left
Description	Each crime may contain one or more evidence.
Properties	has-A
Ratio	1:N
Participation	Crime: partial participation Evidence: total participation
Attributes	-

Name of relationship	possessed
Description	Each offender may possess one or more weapons.
Properties	has-A
Ratio	1:N
Participation	Offender: total participation Weapon: total participation
Attributes	-

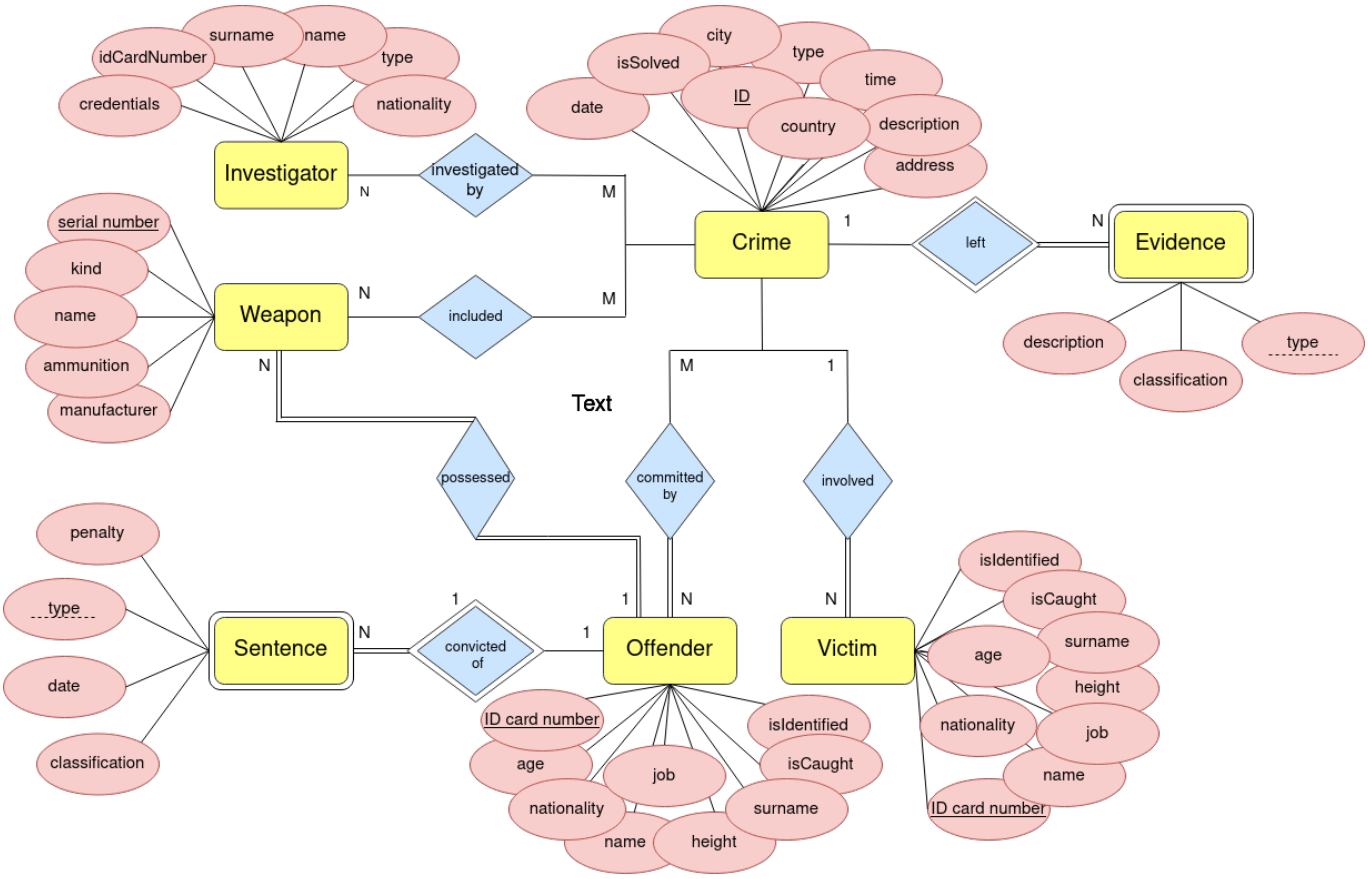
Name of relationship	investigated by
Description	Each crime has a number of investigators, responsible for its investigation.
Properties	has-A
Ratio	M:N
Participation	Investigator: total participation Crime: partial participation
Attributes	- investigator.Id - crime.Id

Name of relationship	convicted_of
Description	Each offender may have been sentenced one or more times.
Properties	has-A
Ratio	1:N
Participation	Offender: partial participation Sentence: total participation
Attributes	-

Name of relationship	committed_by
Description	Each crime must have been committed by one or more offenders.
Properties	committed by-A
Ratio	M:N
Participation	Crime: partial participation Offender: total participation
Attributes	- crime.ID - offender.idCardNumber

Name of relationship	involved
Description	Each crime may involve one or more victims.
Properties	has-A
Ratio	1:N
Participation	Victim: total participation Crime: partial participation
Attributes	-

3.4 Entity-Relationship Diagram



4 Relational Model

This section contains all the necessary information regarding the relational model, including the domain in which every variable is defined. The relational model is presented via both arrays of relations, and the relational diagram.

4.1 Domain

Domain	Type
idCode	CHAR(10)
condition	BOOL
date	DATE
time	TIME
number	INT
string	VARCHAR(20)
location	VARCHAR(15)
crime_category	ENUM('Felonies', 'Misdemeanors', 'Infraction')
evidence_category	ENUM('Real Evidence', 'Testimonial Evidence', 'Demonstrative Evidence', 'Documentary Evidence')
weapon_category	ENUM('Artillery', 'Biological', 'Chemical', 'Firearm', 'Explosives', 'Combat')
investigator_type	ENUM('Police', 'Forensics', 'Computer Crime')
text	VARCHAR(200)

4.2 Relations

Crime	
Variables	
Name	**Type**
ID	idCode
date	date
time	time
isSolved	condition
type	crime_category
Integrity Restrictions	
Primary Key	ID
Foreign Key	

Weapon	
Variables	
Name	**Type**
serialNumber	idCode
kind	weapon_category
name	string
manufacturer	string
ammunition	string
Integrity Restrictions	
Primary Key	serialNumber
Foreign Key	offenderId (Offender)

Investigator	
Variables	
Name	**Type**
idCardNumber	idCode
name	string
surname	string
nationality	string
credentials	text_category
type	investigator_type
Integrity Restrictions	
Primary Key	idCardNumber
Foreign Key	

Crime Investigated By Investigator	
Variables	
Name	Type
investigatorIdCardNumber	idCode
crimeId	idCode
Integrity Restrictions	
Primary Key	investigatorIdCardNumber, crimeId
Foreign Key	

Offender	
Variables	
Name	**Type**
idCardNumber	idCode
age	number
name	string
surname	string
height	number
job	string
nationality	string
isIdentified	condition
isCaught	condition
Integrity Restrictions	
Primary Key	idCardNumber
Foreign Key	

Crime Committed By Offender	
Variables	
Name	Type
crimeId	idCode
offenderId	idCode
Integrity Restrictions	
Primary Key	offenderId, crimeId
Foreign Key	

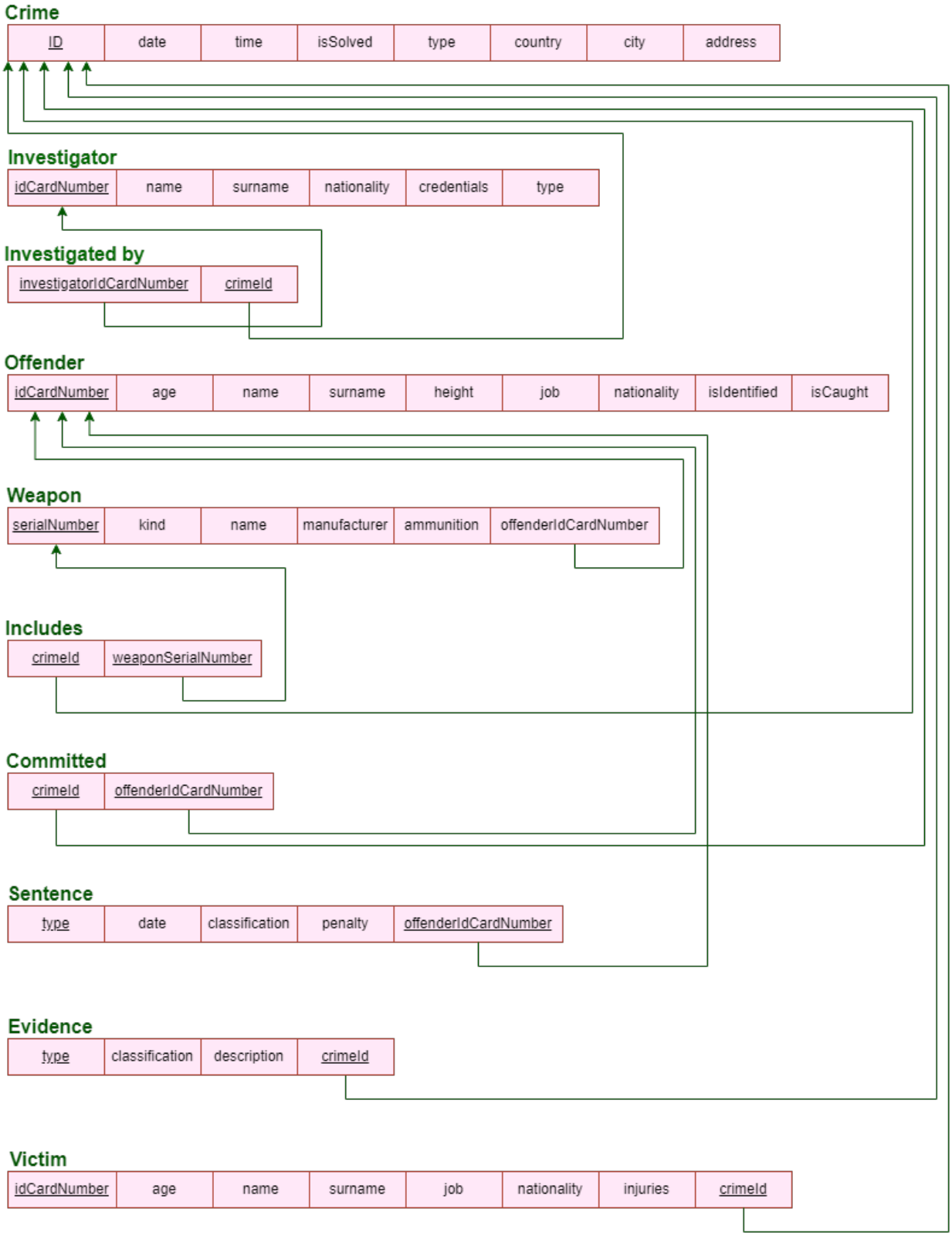
Victim	
Variables	
Name	**Type**
idCardNumber	idCode
age	number
name	string
surname	string
job	string
nationality	string
injuries	text
Integrity Restrictions	
Primary Key	idCardNumber
Foreign Key	crimeId (Crime)

Sentence	
Variables	
Name	**Type**
classification	crime_category
type	string
date	date
penalty	text
Integrity Restrictions	
Partial Key	type
Foreign Key	offenderId (Offender)

Evidence	
Variables	
Name	**Type**
classification	evidence_category
type	string
description	text
Integrity Restrictions	
Partial Key	type
Foreign Key	crimeId (Crime)

Crime Includes Weapon	
Variables	
Name	**Type**
crimeId	idCode
weaponSerialNumber	idCode
Integrity Restrictions	
Primary Key	crimeId, weaponSerialNumber
Foreign Key	

4.3 Relational Diagram



4.4 Views

In this paragraph, we present some views, i.e result sets of stored query on the data. The specified views of the Forensics Database are highly expected to correspond to a large number of user requests. Each view is described in relational Algebra.

4.4.1 Return all the crimes, including any involved offenders, victims and investigators (involved$_{i}n_{c}rimes$)

$$A \leftarrow \rho_{CRIME(crimeId)}(\pi_{ID}(CRIME)) \triangleleft_{ID,crimeId}(\pi_{idCardNumber,crimeId}(VICTIM))$$

$$B \leftarrow \rho_{B(crId,vicId,offId)}((A) \bowtie_{A.crimeId=COMMITTED.crimeId}(COMMITTED))$$

$$C \leftarrow (B) \bowtie_{B.crId=crimeId}(INVESTIGATED)$$

$$\pi_{crId,vicId,offId,investigatorIdCardNumber}(C)$$

4.4.2 How many victims per city (victims$_{p}er_{c}ity$)

$$A \leftarrow \rho_{CRIME(crimeId)}(\pi_{ID}(CRIME)) \triangleright_{ID,victim.crimeId}(VICTIM)$$

$$city\,\mathcal{G}_{count(idCardNumber)\ as\ numOfVictims}(A)$$

5 Examples

5.1 Arrays

Crime

ID	date	time	type	isSolved	country	city	address	description
a090032011	1999-05-16	null	Misdemeanor	true	Greece	Thessaloniki	Stamatelou 1	Illegal substance possession
a334499894	2021-05-13	13:00	Felony	true	Greece	Karditsa	Zafeiriou 1	Arson
e22222222	2018-11-11	22:00	Felony	false	Greece	Xanthi	Larissis 4	Serious physical harm
E455598990	2005-03-01	21:30	Felony	false	Greece	Athens	Lahana 12	Serious physical harm
e99999999	2021-04-29	17:40	Misdemeanor	true	Greece	Athens	Verginas 9	null
i001111111	2021-11-30	00:00	Misdemeanor	true	Greece	Thessaloniki	Egnatias 12	Vandalism
j001222222	2010-01-24	15:00	Felony	true	New Zealand	null	null	null
L998455500	2017-11-28	null	Misdemeanor	true	Greece	Drama	Patroklou 23	Drunk driving
Q99999999	2017-05-01	null	Felony	true	Greece	Larissa	null	Burglary
R433339677	2000-12-30	16:00	Infraction	false	Greece	Alexandroupoli	null	speeding
r444444444	2017-01-01	null	Felony	true	Greece	Irakleio	null	Murder
r555555555	2019-03-06	null	Misdemeanor	true	America	Texas	null	Tresspassing
S334455712	2020-07-24	null	Felony	true	Greece	Thessaloniki	Lefkipou 45	Forgery
t020000011	2021-03-11	null	Misdemeanor	true	America	null	null	null
w00000000	2016-09-14	12:30	Infraction	false	Greece	Larissa	Ipikourou 1	Shoplifting

Weapon

serialNumber	kind	name	manufacturer	ammunition	offenderID
ee3333333	Combat	brick	null	null	EE777777
er9999990	Firearm rifle	AR15	Sig Sauer & Koch	5.56 x 45mm	AK558922
lo0000000	Combat	chain	null	null	II232323
po1200999	Firearm	M416	Heckler/Koch	9mm	EP044982
pp0000000	Combat rifle	pike	null	null	ER999999
qq1233444	Combat	iron knucles	null	null	TU122233
qw1234567	Combat	knife	SAAB AB	null	EQ880022
re3333333	Firearm rifle	S12	Heckler/Kock	12 gayge	SD002234
ri9922111	Combat	club	null	null	OO111111
rt9912344	Firearm	P9	Sig Sauer	9mm	ET003445
sf1244332	Combat	baseball bat	null	null	FL1339911
we1455812	Chemical rifle	HCL	null	null	TU122233
ww1222344	Chemical	acid	null	null	ST333333

Investigator

idCardNumber	type	name	surname	nationality	credentials
CF009112	Computer Crime	Marshal	Walker	American	BSc in Computer Science
CN311009	Forensics	Olliver	Smith	England	BSc in Biology
EE112233	Forensics	Maria	Spurou	Greek	BSc in Biology
KK009942	Police	Jason	Myers	American	MSc in Chemistry
OI998344	Police	Andronikos	Petrou	Greek	NULL
PO241122	Forensics	Lin	Xiaojun	Chinese	MSc in Chemistry
QA994400	Police	Kylian	Jackson	American	NULL
UQ009943	Forensics	Justin	Lee	Japanese	MSc in Forensics Science
WW002321	Forensics	Spuridoula	Vlahou	Greek	MSc in Forensics Science

Offender

idCardNumber	age	name	surname	height	job	nationality	isIdentified	isCaught
AK558922	47	Konstantinos	Papadopoulos	1.78	Fisherman	Greek	true	false
EE777777	41	Larry	Peterson	2.03	Seller	American	true	false
EP044982	55	Paulos	Paulou	1.69	Delivery	Greek	true	true
EQ880022	49	Petros	Zivkovic	1.74	Doctor	Serbian/Greek	true	true
ER999999	31	Marquines	Dickinson	null	Computer Engineer	Spanish	true	true
ET003445	16	Igor	Dobromir	1.83	null	Bulgarian	true	true
FL1339911	17	Marios	Zafeiris	1.87	null	Greek	true	true
II232323	37	Shawn	Mercury	1.81	null	English	true	true
OO111111	17	Marshal	Kostoglou	1.64	null	Greek/American	true	true
SD002234	61	Dmitri	Smirnov	1.85	Taxi Driver	Russian	true	true
ST333333	28	Rio	Cortez	null	Computer Scientist	Spanish	true	true
TU122233	34	Eddy	Gjergji	1.91	null	Albanian	true	false

Victim

idCardNumber	age	name	surname	job	nationality	injuries	crimeID
DS348912	19	Vasiliki	Pagkalou	null	Greek	null	a090032011
EE322119	71	Christin	Nalewanjy	null	Japanese	null	a334499894
FF431232	23	Elsa	Pruskova	null	Russian	null	E455598990
IO099919	25	Dimitra	Williams	null	Greek/American	null	L998455500
JJ451234	54	Giannis	Panagiotopoulos	null	Greek	null	S334455712
XC000000	45	Christos	Petrou	null	Greek	null	R433339677

Sentence

classification	type	date	penalty	ID
Misdemeanor	robbery	1999-09-10	null	EP044982
Misdemeanor	robbery	2000-12-30	null	EQ880022
Misdemeanor	robbery	2010-02-10	null	ER999999
Infraction	null	2008-10-20	100 euros	ET003445
Misdemeanor	burglary	0000-00-00	null	ET003445
Felony	kidnapping	2017-03-04	null	FL1339911
Infraction	null	1998-02-03	null	OO111111
Infraction	null	2005-03-02	null	SD002234
Infraction	null	2008-10-20	null	ST333333

Committed by

offenderIdCardNumber	crimeId
Q99999999	AK558922
e99999999	EE777777
r444444444	EE777777
S334455712	EP044982
t020000011	EQ880022
i001111111	ER999999
S334455712	ER999999
a090032011	ET003445
a334499894	ET003445
E455598990	ET003445
L998455500	ET003445
w00000000	ET003445
a090032011	FL1339911
R433339677	FL1339911
R433339677	OO111111
a090032011	SD002234
e22222222	SD002234
j001222222	SD002234
Q99999999	SD002234
i001111111	ST333333
L998455500	TU122233
S334455712	TU122233

Includes

weaponSerialNumber	crimeId
e99999999	ee3333333
r444444444	ee3333333
Q99999999	er9999990
r555555555	lo0000000
e22222222	po1200999
E455598990	po1200999
S334455712	po1200999
i001111111	pp0000000
a090032011	qq1233444
S334455712	qq1233444
t020000011	qw1234567
E455598990	re3333333
j001222222	re3333333
Q99999999	re3333333
R433339677	ri9922111
a090032011	rt9912344
a334499894	rt9912344
L998455500	rt9912344
a090032011	sf1244332
R433339677	sf1244332
L998455500	we1455812
i001111111	ww1222344

Evidence

type	classification	description	description
Documentary	post letter	null	a090032011
Testimonial	witness	null	a090032011
Documentary	finger print	null	a334499894
Real	notes	null	e22222222
Real	scence's photo	null	e22222222
Real	DNA	null	E455598990
Testimonial	DNA	null	e99999999
Real	witness	null	i001111111
Real	knife	null	j001222222
Testimonial	shoe	null	L998455500
Real	anonymous witness	null	Q99999999
Real	DNA	null	r444444444

5.2 Requests

Finally, we present some possible requests that a user might consider helpful. Once again, each request is described using relational Algebra.

5.2.1 Return the crimes, committed by underage offenders

$$(\pi_{ID,idCardNumber}(CRIME) \bowtie_{OFFENDER.age<18}(OFFENDER)) \cap (INCLUDES)$$

5.2.2 Return the crimes that were witnessed by at least one person

$$\pi_{ID}((CRIME) \bowtie_{ID=E.crId \bigwedge E.c='RealEvidence'} \rho_{E(crId,t,c,d)}(EVIDENCE))$$

or

$$A \leftarrow (CRIME) \bowtie_{ID=E.cId} \rho_{E(cId,t,c,d)}(\sigma_{EVIDENCE.class='RealEvidence'}(EVIDENCE))$$
$$\pi_{ID}(A)$$

5.2.3 How many robberies has each offender committed

$$A \leftarrow (OFFENDER) \bowtie_{type='robbery' \bigwedge ID=offenderId} (SENTENCE)$$
$$idCardNumber\, \mathcal{G}_{count(type)\ as\ numOfRobberies}(\pi_{type,date,idCardNumber}(A))$$

5.2.4 Which crimes occurred in Thessaloniki during the last year

$$\pi_{ID}(\sigma_{date>2020 \bigwedge city='Thessaloniki'}(CRIME))$$

5.2.5 What type of crimes do underage people usually do

$$\pi_{type}(((CRIME) \bowtie_{OFFENDER.age<18}(OFFENDER)) \div (COMMITTED))$$

5.2.6 Gun-involving crimes, in which DNA was found as evidence

$$A \leftarrow (CRIME) \bowtie_{ID=E.crId \bigwedge E.t='DNA'} (\rho_{E(crId,t,c,d)}(EVIDENCE))$$
$$B \leftarrow (\pi_{ID,crimeId}((CRIME) \bowtie_{ammunition \neq null}(WEAPON))) \cap (INCLUDES)$$
$$\pi_{ID,weaponSerialNumber}((A) \triangleleft_{\theta} (B))$$

5.2.7 Crimes solved by each investigator

$$A \leftarrow (INVESTIGATED) \bowtie_{id=crimeId} (\sigma_{isSolved=1}(CRIMES))$$
$$B \leftarrow (A) \bowtie_{idCardNumber=investigatorId} (INVESTIGATORS)$$
$$investigatorId\, \mathcal{G}_{count(crimeId)\ as\ resolvedCrimes}(\pi_{investigatorId,crimeId}(B))$$

5.2.8 Criminal records of serious offenders

$$A \leftarrow (COMMITTEDBY) \bowtie_{crimeId=id} (\sigma_{type='Felony' || type='Misdemeanor'}(CRIMES))$$
$$B \leftarrow (A) \bowtie_{idCardNumber=offenderId} (OFFENDERS)$$
$$\pi_{offenderId,name,surname,type,date,penalty}(B) \bowtie_{idCardNumber=offenderId} (SENTENCES)$$

5.2.9 Criminal records of serious offenders

$$A \leftarrow \mathcal{G}_{count(type)\, as\, felonies}(\sigma_{type='Felony'}(CRIMES))$$

$$B \leftarrow \mathcal{G}_{count(type)\, as\, misdemeanors}(\sigma_{type='Midemeanor'}(CRIMES))$$

$$C \leftarrow \mathcal{G}_{count(type)\, as\, infractions}(\sigma_{type='Infraction'}(CRIMES))$$

$$D \leftarrow (A) \rtimes (B) \cup (A) \ltimes (B)$$

$$(D) \rtimes (C) \cup (D) \ltimes (C)$$