A music database consists of the following preliminary specification:

Music Database Relations
Musicians {Mno, MName, MDoB, MCountry} PK [Mno]
Compositions {Cno, CTitle, CMno, CDate} PK [Cno]; FK [CMno references **Musicians**]
Ensembles {Eno, EName, ECountry, EMnoMgr} PK [Eno]; FK [EMnoMgr references **Musicians**]
Performances {Pno, PDate, PCno, PCity, PCountry, PEno} CKs [PDate, PEno], [Pno] ; FK [PCno references **Compositions**]; FK [PEno references **Ensembles**]
Ensemble_Members {EmEno, EmMno, EmInstrument} PK [EmEno, EmMno]; FK [EmEno references **Ensembles**]; FK EmMno references **Musicians**]

Question 1:
Prepare a database specification (either a RAL or an ESG showing database-related details only) for the database. This database specification may be refined by introducing a sixth relational table, and adjusting three other tables to each have a foreign key that references this additional table.

1a. Identify the additional table that is required, and clearly describe the adjustments that need to be made to three tables in order to have a normalized database. [08]

The additional table is **Countries** {CnCode, CnName} PK [Cncode]

The tables **Musicians**, **Ensembles**, and **Performances** should be adjusted to each have a foreign key referencing **Countries**.

1b. Propose an ESG or RAL that provides specifications for the six relational tables of the music database. [36]

Entity	Properties	Comment
Counties	CnCode [A4]	PK
	CnName [A35]	
Musicians	MNo [N7]	PK
	MName [A40]	
	MDoB [N8]	
	MCountry [A4]	FK References **Countries.CnCode**
Compositions	CNo [A6]	PK
	CTitle [A30]	
	CMNo [N7]	FK References **Musicians.MNo**
	CDate [N8]	
Ensembles	ENo [A6]	PK
	EName [A30]	
	ECountry [A4]	FK References **Countries.CnCode**
	EMnoMgr [N7]	FK References **Musicians.MNo**
Performances	PNo [A6]	PK
	PDate [N8]	
	PCNo [A6]	FK References **Compositions.CNo**
	PCity [A30]	
	PCountry [A4]	FK References **Countries.CnCode**
	PENo [A6]	FK References **Ensembles.ENo**
Ensemble_Members	EmENo [A6]	FK References **Ensembles.ENo** [K1]
	EmMNo [N7]	FK References **Musicians.MNo** [K2]
	EmInstrumment [A30]	

1c. Provide some sample data for the music database. You data should demonstrate that you understand the important role of foreign keys. [10]

Countries:

CnCode	CnName
ENG	England
FRN	France
JAM	Jamaica
USA	United States of America

Musicians:

Mno	MName	MCountry
M001	Bruce Jones	USA
M002	David Foster	USA
M003	Roger Williams	USA
M004	A. L. Weber	ENG
M100	Mozart	RUS
M200	C. Debussy	FRN
M300	R. Marley	JAM
M320	M. Hague	JAM
...		

Compositions:

Cno	CTitle	CMno	CDate
C001	One Love	M300	19761201
C099	Chariots of Fire	M002	19720101
C100	Free	M320	19890201
C101	Rise Again	M003	19820612
C199	Moonlight	M004	19790901
...			

Ensembles:

Eno	EName	ECountry	EMnoMgr
E01	NY Philharmonic	USA	M002
E02	London Ensemble	ENG	M004
...			
E99	Jamaica Ensemble	JAM	M320

Performances:

PNo	PDate	PCno	PCity	PCountry	PEno
1995001	19950101	C100	KGN	JAM	E01
1995002	19950101	C100	NY	USA	E99
1995003	19950101	C099	LA	USA	E02
1995004	19950101	C099	WDC	USA	E01
...					

Ensemble_Members:

EmEno	EmMno	EmInstrument
E01	M001	Clarinet
E01	M004	Clarinet
E01	M100	Saxophone
E02	M200	Saxophone
E02	M300	Saxophone
E02	M320	Flute
E03	M300	Clarinet
...		

Question 2:
Write relational calculus statements to realize the following:

2a. List the registered musicians from USA or JAM (where "USA" and "JAM" are abbreviated codes for United States and Jamaica respectively). [03]

RANGE OF M is Musician;
M•MNo WHERE (M • MCountry = 'USA') OR (M • MCountry = 'JAM');

2b. Give the Eno & EName of every ensemble that includes a SAXAPHONE or CLARINET player. [03]

RANGE OF EM is Ensemble_Members; RANGE of E is Ensembles;
E•EName, EM•EmENo WHERE (EM•EmInstrument = 'SAXOPHONE' OR EM•EmInstrument = 'CLARINET')
AND (EM•EmENo = E•ENo);

2c. Give the the Eno & EName of every ensemble that includes a SAXAPHONE but not a CLARINET player. [04]

Note: By DeMorgan's theorem A• B' = (A' + B)'.

RANGE OF EM1 is Ensemble_Members; RANGE OF EM2 is Ensemble_Members; RAMGE of E is Ensembles;
EM1•EmENO WHERE (NOT (EM1•EmInstrument <> 'SAXOPHONE' OR EM2•EmInstrument = 'CLARINET')
AND EM1•EmENo = EM2•EmENo AND EM1•EmENo = E•ENo);

Alternately we may have the following:

RANGE OF EM1 is Ensemble_Members; RANGE OF EM2 is Ensemble_Members; RAMGE of E is Ensembles;
E•EName, EM1•EmENo WHERE (EM1•EmInstrument = 'SAXOPHONE' AND NOT EXISTS EM2
(EM2•EmInstrument = 'CLARINET' AND EM1•EmENo = EM2•EmENo) AND EM1•EmENo = E•ENo);

2d. List all compositions (Cno and CTitle) by MOZART [04]

RANGE of C is Compositions;
RANGE of M is Musicians;
C•CNO, C•CTitle WHERE EXISTS M(C•CMNo = M•MNo AND M•MName = 'MOZART');

2e. List all performances (PNO PCNO MNO & PCOUNTRY) of compositions in the country of origin. [06]

RANGE OF P is Performances;
RANGE OF C is Compositions;
RANGE OF M is Musicians; RANGE OF M2 is Musicians;
(P•PNo, P•PCNo, M2•MNo, P•PCountry)
WHERE EXISTS C EXISTS M (P•PCNo = C•CNo AND C•CMNo = M•MNo AND M•MCountry = P•PCountry
AND M•MNo = M2•MNo);

Alternate solution:

RANGE OF P is Performances;
RANGE OF C is Compositions;
RANGE OF M is Musicians;
(P•PNo, P•PCNo, C•CMNo, P•PCountry)
WHERE EXISTS C EXISTS M (P•PCNo = C•CNo AND C•CMNo = M•MNo AND M•MCountry = P•PCountry);

2f. Give the Eno & EName of every ensemble that includes a SAXAPHONE or CLARINET player, but not both. [06]

RANGE OF EM1 is Ensemble_Members; RANGE OF EM2 is Ensemble_Members; RANGE of E is Ensembles;
E●EName, EM1●EmENo WHERE (EM1●EmInstrument = 'SAXAPHONE' OR EM1●EmInstrument = "CLARINET' AND NOT EXISTS EM2 ((EM1●EmInstrument = 'SAXAPHONE' AND EM2●EmInstrument = "CLARINET' AND EM1 ● ENo = EM2●EmENo) OR (EM1●EmInstrument = 'CLARINET' AND EM2●EmInstrument = "SAXOPHONE' AND EM1●EmENo = EM2●EmENo) AND EM1●EmENo = E●ENo);

Alternate Solution: Note that this situation describes an exclusive-or application:
A ⊕ B = A●B' + A'●B
A: EM1●EmInstrument = 'SAXOPHONE'
B: EM2●EmInstrument = 'CLARINET'

RANGE OF EM1 is Ensemble_Members; RANGE OF EM2 is Ensemble_Members; RANGE of E is Ensembles;
E●EName, EM1●EmENo WHERE (EXISTS EM2
((EM1●EmInstrument <> 'SAXOPHONE' AND EM2●EmInstrument = 'CLARINET'AND EM1●EmENo = EM2●EmENo) OR
(EM1●EmInstrument = 'SAXAPHONE' AND EM2●EmInstrument <> 'CLARINET'AND EM1●EmENo = EM2●EmENo))
AND EM1●EmENo = E●ENo)

2g. Find Cno & CTitle for compositions all of which have been performed in USA. [03]

RANGE OF P is Performances; RANGE of C is Compositions;
P●PCNO, C.CTitle WHERE P●PCountry = 'USA' AND P●PCNo = C●CNo;

2h. List countries in which MOZART's compositions have been performed. [04]

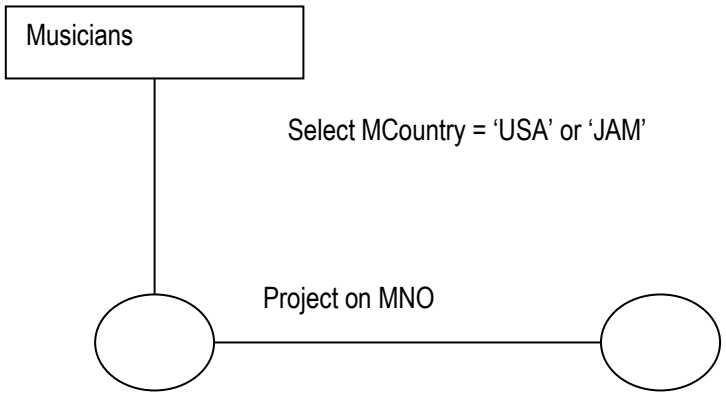
RANGE OF P is Performances;
RANGE OF C is Compositions;
RANGE OF M is Musicians;
P●PCountry WHERE EXISTS C EXISTS M
(C●CNO = P●PCNo AND C●CMNo = M●MNo AND M●MName = 'MOZART');

2i. Give EName of ensembles whose manager is JAMAICAN. [03]

RANGE OF E is Ensembles;
RANGE OF M is Musicians;
E●EName WHERE EXISTS M (M●MNo = E●EMnoMgr AND M●MCountry = 'JAM');

Question 3:
Write relational algebra statements corresponding to relational calculus statements of question 2.

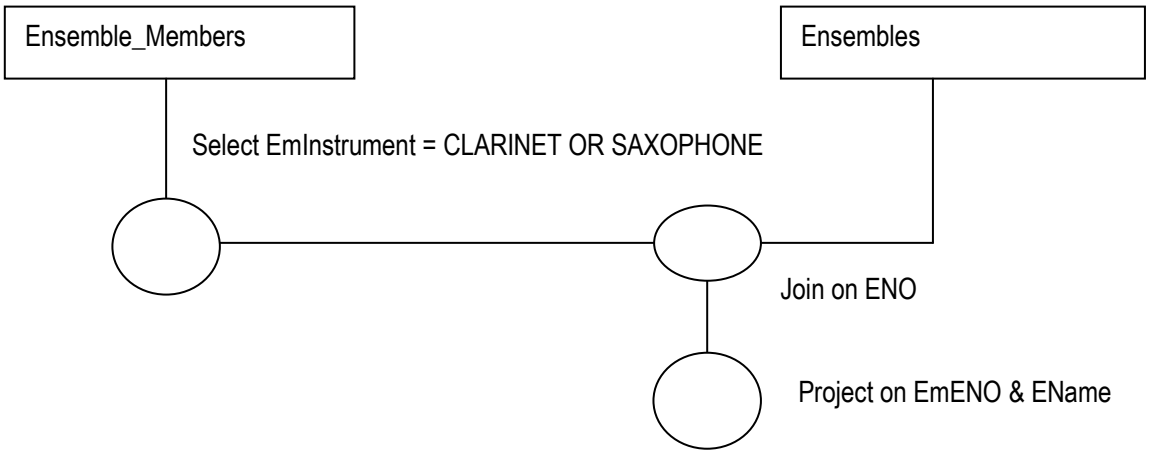
3a. List the registered musicians from USA or JAM (where "USA" and "JAM" are abbreviated codes for United States and Jamaica respectively). [03]



The algebra specification is:

Ullman Notation: PROJ MNO (SELECT MCountry = 'JAM' OR MCountry = 'USA' (Musicians))
Date Notation: MNO FROM Musicians WHERE MCountry= 'JAM' OR MCountry = 'USA'

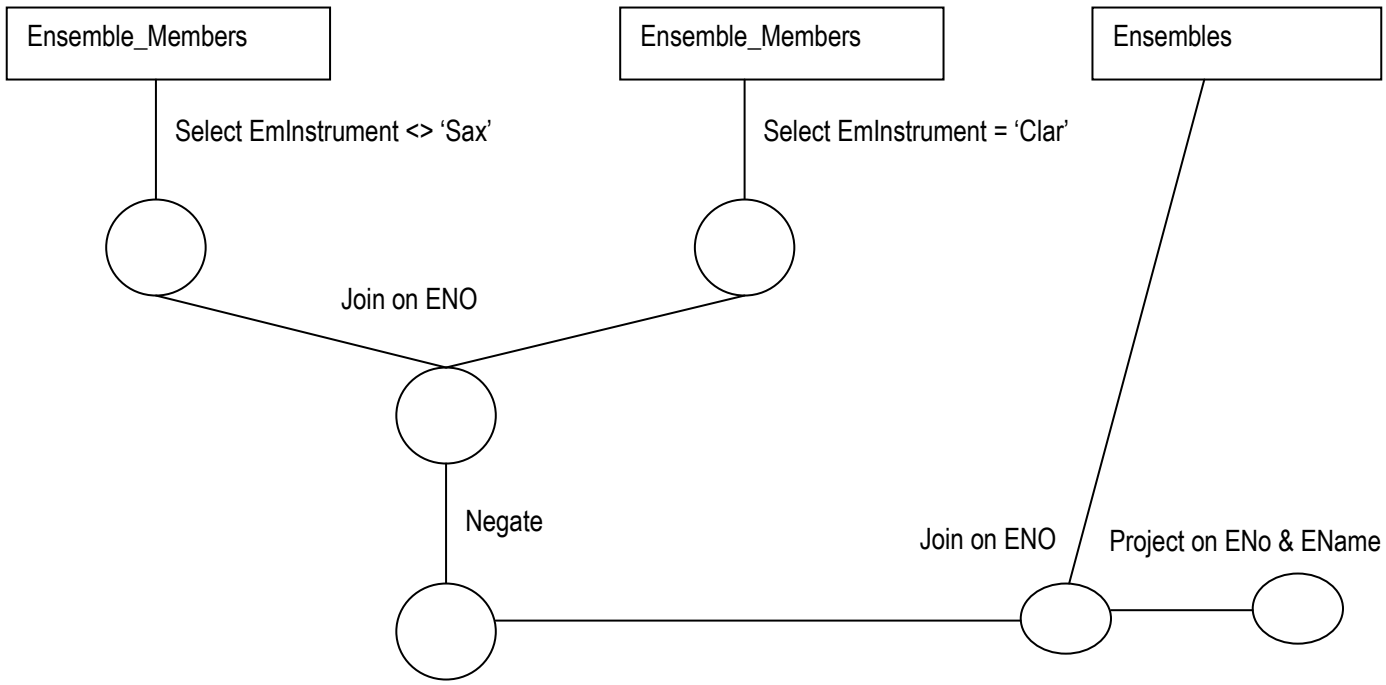
3b. Give the Eno & EName of every ensemble that includes a SAXAPHONE or CLARINET player. [03]



The algebra specification is

EM ALIASES Ensemble_Members; E ALIASES Ensembles;
Ullman Notation: PROJECT EName, EmENo (SELECT Em Instrument = 'SAXOPHONE' OR EmInstrument = 'CLARINET' (EM) JOIN (EM•EmENo = E•ENo) E)
Date Notation: EName, EmENO FROM EM JOIN (EM•EmENo = E•ENo) E WHERE EmInstrument = 'SAXOPHONE' OR EmInstrument = 'CLARINET'

3c. Give the the Eno & EName of every ensemble that includes a SAXAPHONE but not a CLARINET player. [04]



The first algebra solution below employs DeMorgan's theorem A● B' = (A'+ B)':

EM1 ALIASES Ensemble_Members; EM2 ALIASES Ensemble_Members; E ALIASES Ensembles;
Ullman Notation(using ANSI join notation): PROJ EmENo, EName (NOT (SELECT EmInstrument <> 'SAXAPHONE' (EM1)) JOIN (EM1.EmENo = EM2.EmENo) (SELECT EmInstrument = 'CLARINET' (EM2))) JOIN (EM1●EmENo = E●ENo) E;
Date Notation (using ANSI join notation): EmENO, EName FROM NOT(EM1 WHERE EmInstrument <> 'SAXAPHONE' JOIN (EM1●EmENo = EM2●EmENo) EM2 WHERE EmInstrument = 'CLARINET')') JOIN (EM1●EmENo = E●ENo) E;

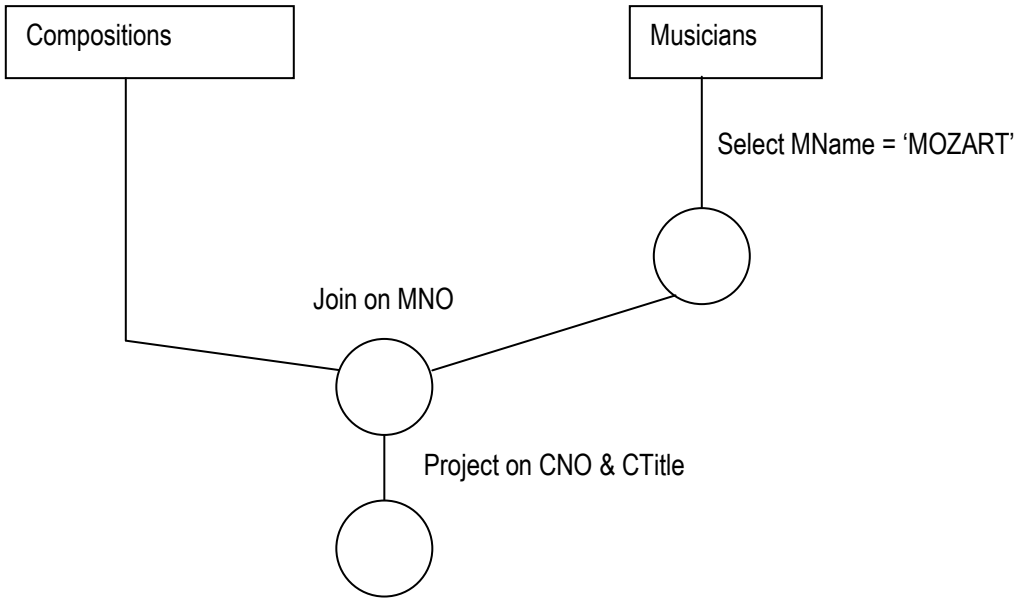
// Alternate simplified specification

EM1 ALIASES Ensemble_Members; E ALIASES Ensembles;
Ullman Notation: PROJ EmENo (SELECT NOT(EmInstrument <> 'SAXAPHONE' OR EmInstrument = 'CLARINET') (Ensemble_Members)) JOIN (EM1●EmENo = E●ENo) E;
Date Notation: EmENO, EName FROM EM1 WHERE NOT(EmInstrument <> 'SAXAPHONE' OR EmInstrument = 'CLARINET') JOIN (EM1●EmENo = E●ENo) E;

// Alternate specification based on the difference-rule:

EM1 ALIASES Ensemble_Members; E ALIASES Ensembles;
Ullman Notation: PROJ EmENo, EName ((SELECT EmInstrument = 'SAXOPHONE' (EM1) MINUS (SELECT EmInstrument = 'CLARINET' (EM1) JOIN (EM1●EmENo = E●ENo) E)
Date Notation: EmENO, EName FROM ((EM1 WHERE EmInstrument = 'SAXOPHONE') MINUS (EM1 WHERE EmInstrument = 'CLARINET') JOIN (EM1●EmENo = E●ENo) E)

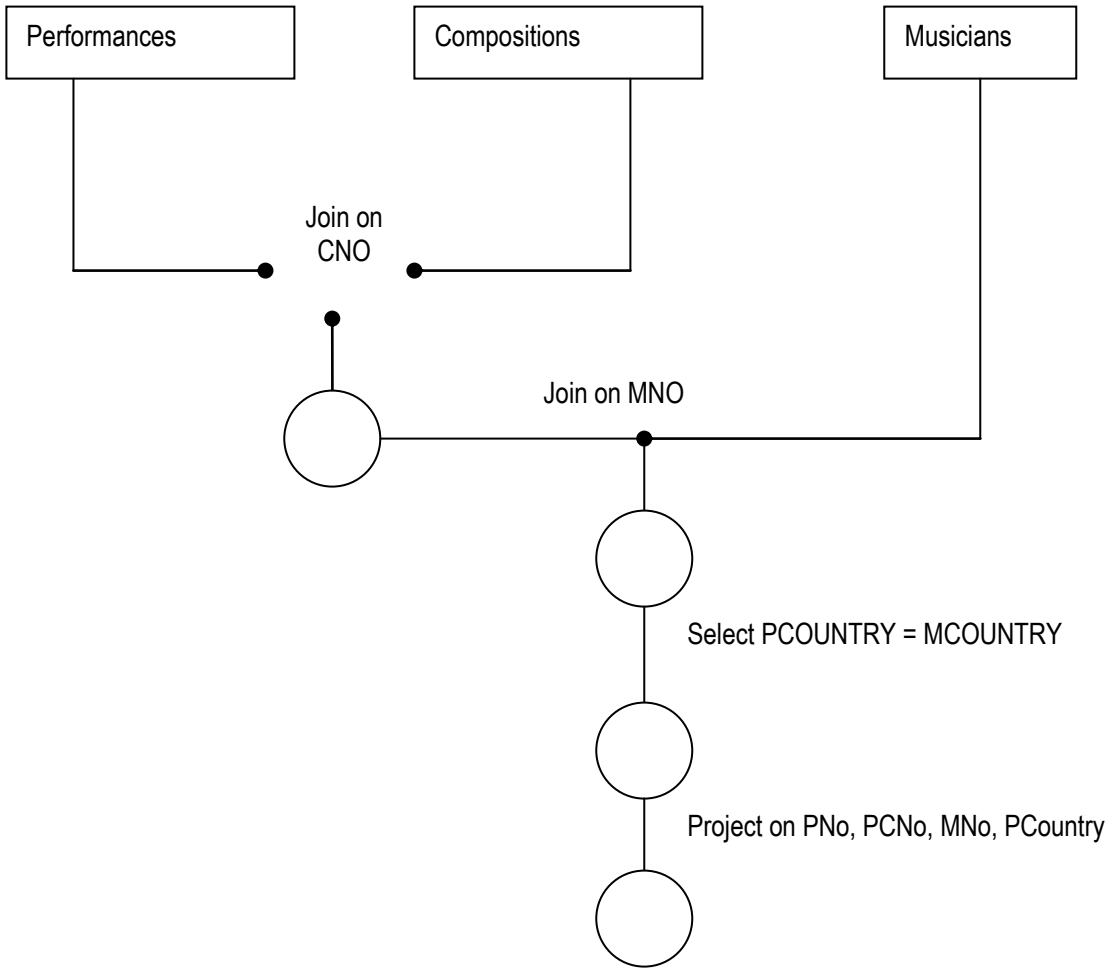
3d. List all compositions (Cno and CTitle) by MOZART [04]



This is an equijoin scenario. The algebra specification is:

M ALIASES Musician; C ALIASES Compositions;
Ullman Notation (using ANSI join notation): PROJ CNo, CTitle (SELECT MName = 'MOZART' (M) JOIN (C•CMNo = M•MNo) C)
Date Notation (using ANSI join notation): CNo, CTitle FROM (M WHERE MName = 'MOZART' JOIN (C•CMNo = M•MNo) C)

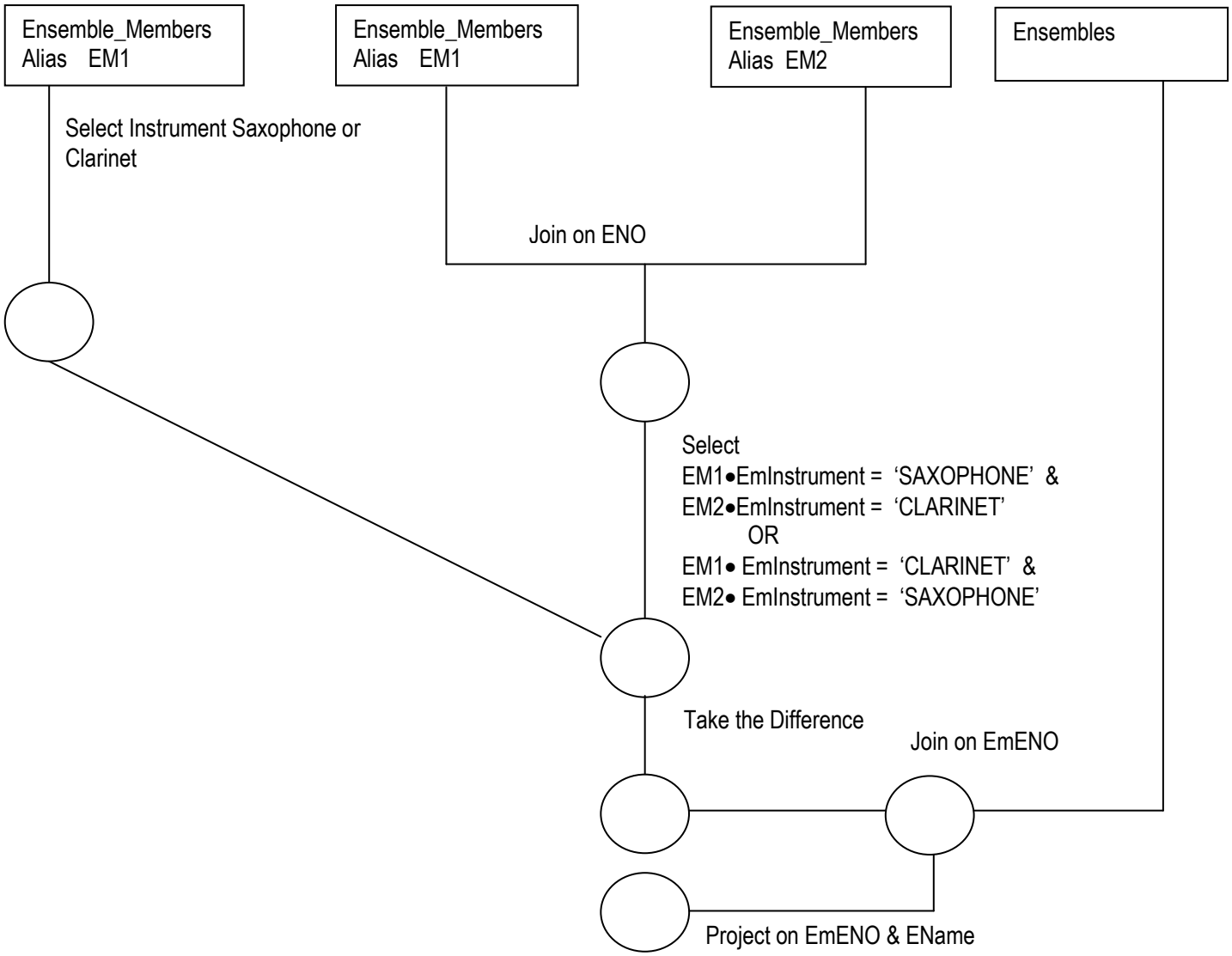
3e. List all performances (Pno, Cno, Mno, & PCountry) of compositions in the country of origin. [06]



This is also an equijoin scenario. The algebra specification is:

C ALIASES Compositions; M ALIASES Musicians; P ALIASES Performances;
Ullman Notation (using ANSI join notation): PROJ P●PNo, P●PCNo, C●CMNo, P●PCountry (SELECT PCountry = MCountry (P JOIN (P●PCNo =C●CNo) C JOIN (C●CMNo = M●MNo) M))
Date Notation (using ANSI join notation): P●PNo, P●PCNo, C●CMNo, P●PCountry FROM (P JOIN (P●PCNo =C●CNo) C JOIN (C●CMNo = M●MNo) M WHERE P●PCountry = M●MCountry

3f. Give the Eno & EName of every ensemble that includes a SAXAPHONE or CLARINET player, but not both. [06]



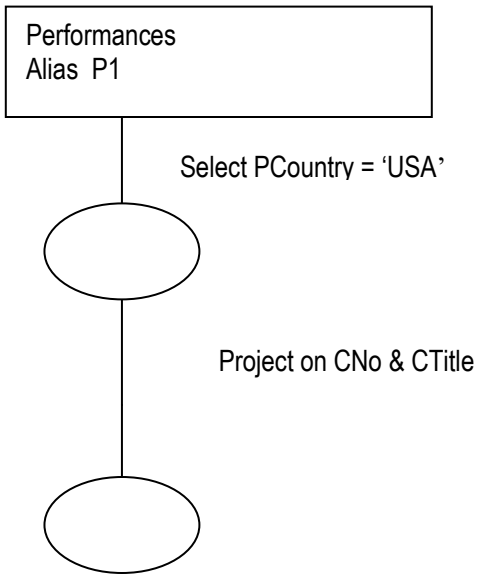
Algebra specification based on the diagram above:

EM1 ALIASES Ensemble_Members; EM2 ALIASES Ensemble_Members; E ALIASES Ensembles;
Ullman Notation (using ANSI join notation): PROJ EM1•EmENO, E•EName ((SELECT (EM1•EmInstrument = 'SAXOPHONE' OR EM1•EmInstrument = 'CLARINET'(EM1)) MINUS PROJ EM1•EmENO (SELECT ((EM1• EmInstrument = 'SAXOPHONE' AND EM2•EmInstrument = 'CLARINET') OR (EM1•EmInstrument = 'CLARINET' AND EM2•EmInstrument = 'SAXOPHONE')) (EM1 JOIN (EM1•EmENO = EM2•EmENO) EM2) JOIN (EM1.EmENo = E•ENo) E);
Date Notation (using ANSI join notation): EM1•EmENo, E•EName FROM ((EM1 WHERE EM1•EmInstrument = 'SAXOPHONE' OR EM1•EmInstrument = 'CLARINET' MINUS EM1 JOIN (EM1•EmENO = EM2•EmENO) EM2 WHERE (EM1• EmInstrument = 'SAXOPHONE' AND EM2• EmInstrument = 'CLARINET') OR (EM1•EmInstrument = 'CLARINET' AND EM2•EmInstrument = 'SAXOPHONE')) JOIN (EM1•EmENo = E•ENo) E);

Alternate algebra specification based on the principle of the exclusive OR:
A ⊕ B = A•B' + A'•B;
A: EM1•EmInstrument= 'SAXOPHONE'
B: EM2•EmInstrument = 'CLARINET'

EM1 ALIASES Ensemble_Members; EM2 ALIASES Ensemble_Members; E ALIASES Ensembles;
Ullman Notation (using ANSI join notation): PROJ EM1•EmENO, E•EName ((SELECT (EM1•EmInstrument <> 'SAXOPHONE' AND EM2•EmInstrument = 'CLARINET') OR (EM1•EmInstrument = 'SAXAPHONE' AND EM2•EmInstrument <> 'CLARINET') (EM1 JOIN (EM1•EmENO = EM2•EmENO) EM2) JOIN (EM1•EmENo = E•ENo) E);
Date Notation (using ANSI join notation): EM1•EmENO, E•EName FROM (EM1 JOIN (EM1•EmENO = EM2•EmENO) EM2 WHERE ((EM1•EmInstrument <> 'SAXOPHONE' AND EM2•EmInstrument = 'CLARINET') OR (EM1•EmInstrument = 'SAXAPHONE' AND EM2•EmInstrument <> 'CLARINET')) JOIN (EM1•EmENo = E•ENo) E);

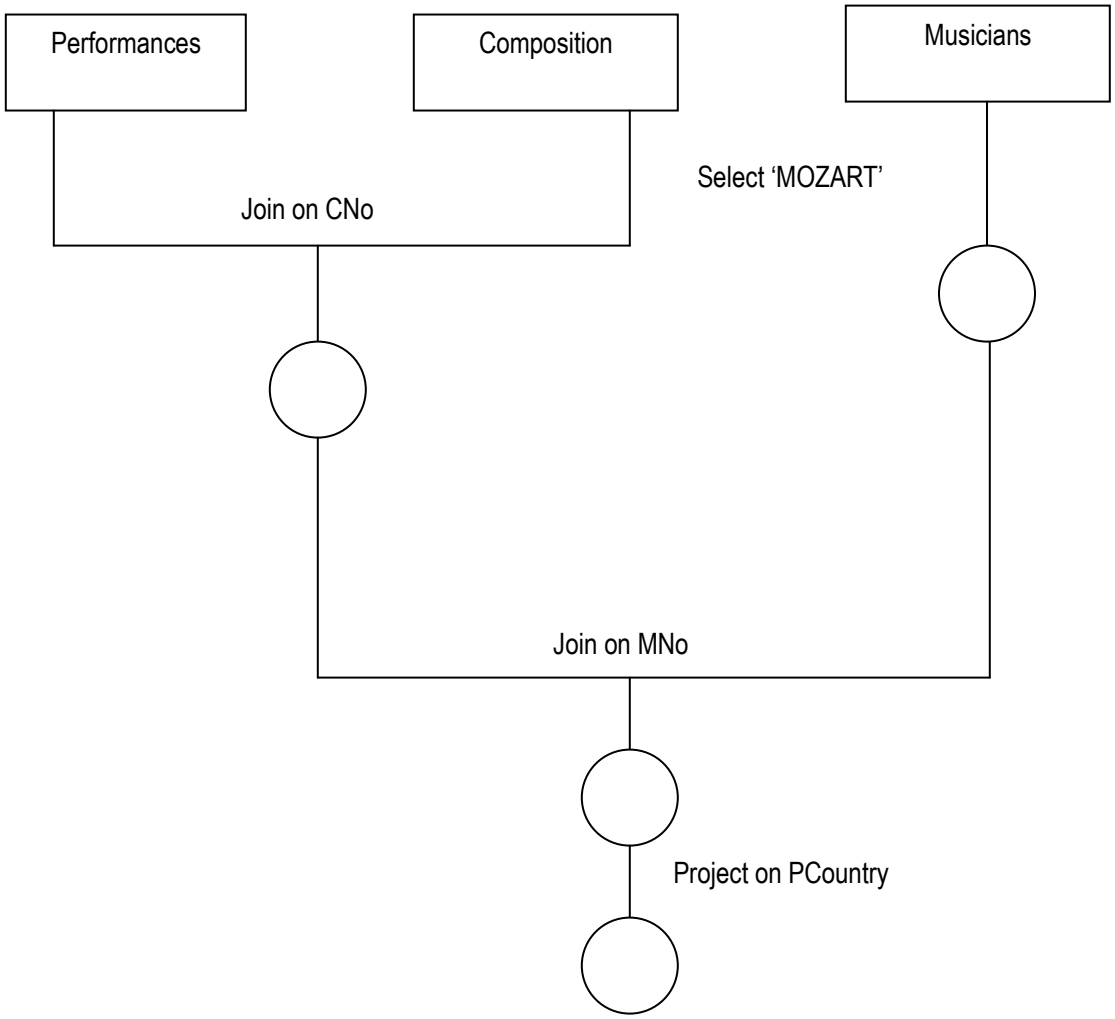
3g. Find Cno & CTitle for compositions all of which have been performed in USA. [03]



The algebra specification is:

Ullman Notation: PROJ PCNo, CTitle (SELECT PCountry = 'USA' (Performance) JOIN (PCNo = CNo) Compositions)
Date Notation: PCNo, CTitle FROM Performances JOIN (PCNo = CNo) Compositions WHERE PCountry = 'USA'

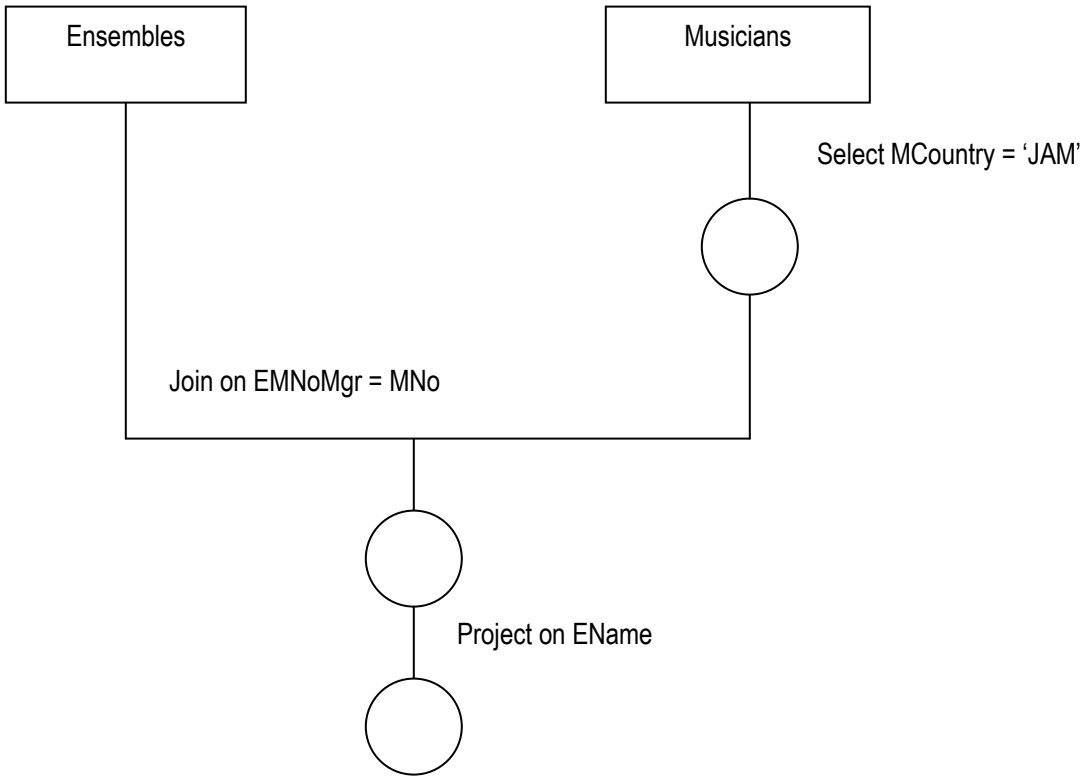
3h. List countries in which MOZART's compositions have been performed. [04]



This is another natural join scenario. The algebra specification is:

P ALIASES Performances; C ALIASES Compositions; M ALIASES Musicians;
Ullman Notation (using ANSI join notation): PROJ PCountry ((P JOIN (P•PCNo = C•CNo) C) JOIN (C•CMNo = M•MNo) SELECT MName = 'MOZART' (M))
Date Notation (using ANSI join notation): PCountry FROM (P JOIN (P•PCNo = C•CNo) C JOIN (C•CMNo = M•MNo) (M WHERE MName = 'MOZART');

3i. Give EName of ensembles whose manager is JAMAICAN. [03]



This is an equijoin scenario. The algebra specification is

Ullman Notation (using ANSI join notation): PROJ EName (Ensembles JOIN (EMnoMgr = MNo) SELECT MCountry = 'JAM' (Musicians))
Date Notation (using ANSI join notation): EName FROM (Ensembles JOIN (EMnoMgr = MNO) (Musicians WHERE MCountry = 'JAM'))