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Config Workshop 2013

Solving Object-oriented Configuration Scenarios with ASP

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Solving Object-oriented Configuration Scenarios with ASP
Answer Set Programming (ASP)

Answer Set Programming (ASP) is a declarative problem solving approach.

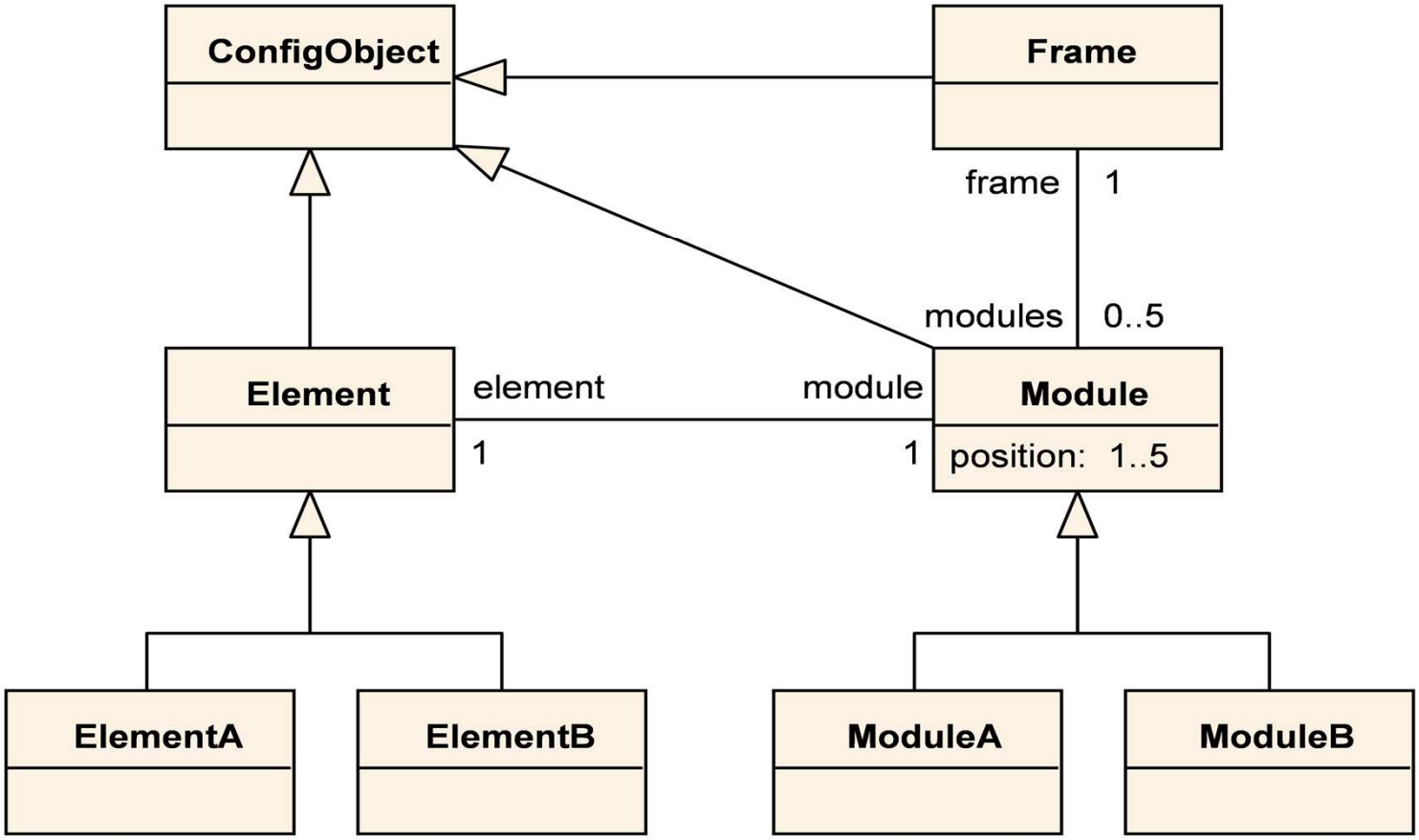
1. Provide a specification (answer set program) of the problem.
2. A solution is given by a model (answer set) of the specification.

```
% Fact
moduleA(m1).
% Rule
module(M) :- moduleA(M).
% Integrity constraint
:- position(M,P),moduleA(M),P=2.
% Cardinality constraint
1{ position(M,1),position(M,2),position(M,3)}1 :- module(M).
% Answer sets
% moduleA(m1) module(m1) position(m1,1)
% moduleA(m1) module(m1) position(m1,3)
```

Potassco – Potsdam Answer Set Solving Collection

http://potassco.sourceforge.net/

Solving Object-oriented Configuration Scenarios with ASP
Object-oriented data model Example UML-Diagram



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OOASP – Object Oriented Answer Set Programming

What is it?

- A schema for describing versioned object oriented (configurator) knowledge bases and their configurations in ASP

What can it be used for?

- Demonstrating different configuration scenarios in ASP (check, complete, reconcile...)
- A schema for representing and sharing object oriented configurator knowledge bases and configurations

What is it not?

- A high performance ASP implementation for doing (re-)configuration

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OOASP - Defining a Knowledge Base

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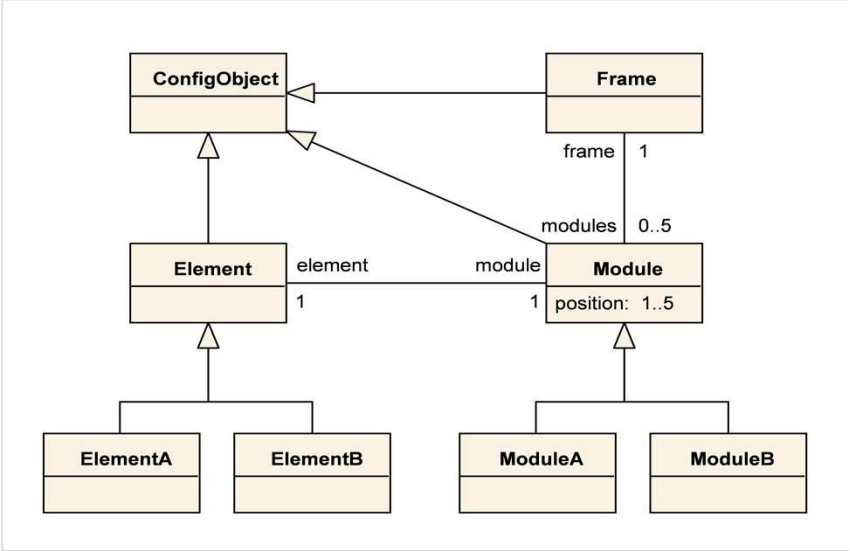
A Knowledge Base is defined with ooasp-facts




```
% Modules example KB "v1"
% ooasp_class(KBID,CID)
ooasp_class("v1","ConfigObject").
...
ooasp_class("v1",“ModuleB").

% ooasp_subclass(KBID,CID,SUPERCID)
ooasp_subclass("v1","Frame","ConfigObject").
...
ooasp_subclass("v1","ModuleB","Module").

% ooasp_attribute(KBID,CID,ATTRID,TYPE)
ooasp_attribute("v1","Module","position","integer").

% ooasp_assoc(KBID,A,CID1,C1MIN,C1MAX,CID2,C2MIN,C2MAX)
ooasp_assoc("v1","Element_module","Element",1,1,"Module",1,1).
ooasp_assoc("v1","Frame_modules",”Frame",1,1,"Module",0,5).
```

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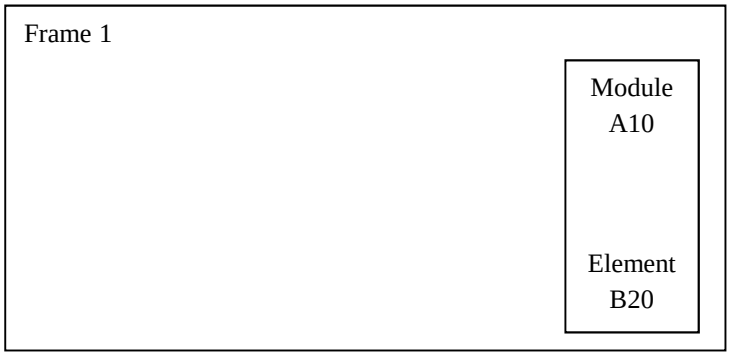
A configuration is an instantiation of the object-model.

```
% every configuration belongs to exactly one knowledge base
ooasp_configuration("v1","c1").
% ooasp_isa(CONFIGID, CID, OBJECTID)
ooasp_isa("c1","Frame",1).
ooasp_isa("c1","ElementB",20).
ooasp_isa("c1","ModuleA",10).
% ooasp_attribute_value(CONFIGID,ATTRID,OBJECTID,VALUE)
ooasp_attribute_value("c1","position",10,5).
% ooasp_associated(CONFIGID,ASSOCID,OBJECTID1,OBJECTID2)
ooasp_associated("c1","Frame_modules",1,10).
ooasp_associated("c1","Element_module",20,10).
```



Solving Object-oriented Configuration Scenarios with ASP
OOASP – Defining Constraints

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A valid configuration is a configuration, where no constraint is violated.
A constraint violation is indicated by deriving ooasp_cv(CONFIGID,INFO).
Two kind of constraints:

- Built-in constraints: Valid for all knowledge bases.
- Domain specific constraints: must be written by knowledge engineer.

Example built-in constraint:

```
ooasp_cv(CONF,mincardviolated(ID1,ASSOC)) :-
  { ooasp_associated(CONF,ASSOC,ID1,ID2): ooasp_isa(CONF,C2,ID2) } C2MIN-1,
  C2MIN>0,
  ooasp_isa(CONF,C1,ID1),
  ooasp_assoc(KBID,ASSOC,C1,C1MIN,C1MAX,C2,C2MIN,C2MAX),
  ooasp_configuration(KBID,CONF).
```

Example domain specific constraint:

```
% ElementA requires ModuleA
ooasp_cv(CONF,wrongModuleType(E,M)) :-
  ooasp_configuration("v1",CONF),
  ooasp_associated(CONF,"Element_module",E,M),
  ooasp_isa(CONF,"ElementA",E),
  not ooasp_isa(CONF,"ModuleA",M).
```

Solving Object-oriented Configuration Scenarios with ASP Scenario Check a Configuration

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Check a Configuration:

Checking a configuration evaluates the constraints of the knowledge base for a configuration under closed world assumption, i.e. during the checking no new objects are instantiated.

Example:

```
ooasp_configuration("v1","c1").
ooasp_isa("c1","Frame",1).
ooasp_isa("c1","ElementB",20).
ooasp_isa("c1","ModuleA",10).
ooasp_attribute_value("c1","position",10,5).
ooasp_associated("c1","Frame_modules",1,10).
ooasp_associated("c1","Element_module",20,10).
```

Result:

```
ooasp_cv(“c1”,wrongModuleType(20,10)).
```

Solving Object-oriented Configuration Scenarios with ASP Scenario Complete a Configuration

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Complete a Configuration:

Given a possible empty (partial) configuration, find an extension of the configuration that satisfies all constraints. No fact of the given configuration may be removed. If no such extension can be found, the current configuration is either inconsistent or there is no valid configuration with the given upper bounds for object instances.

Additional predicate needed for controlling object instantiation:

ooasp_domain(CONFIGID, CID, OBJID)

- The object with the OBJID can be instantiated to one of the leaf-classes of class CID.

```
% Rule for instantiation of objects
0 { ooasp_isa(CONF,LEAFCLASS,ID) :
    ooasp_leafclass(V,LEAFCLASS) :
    ooasp_canbe(CONF,LEAFCLASS,ID) } 1 :-
  ooasp_domain(CONF,C,ID),
  ooasp_configuration(V,CONF).
```

Solving Object-oriented Configuration Scenarios with ASP Scenario Complete a Configuration

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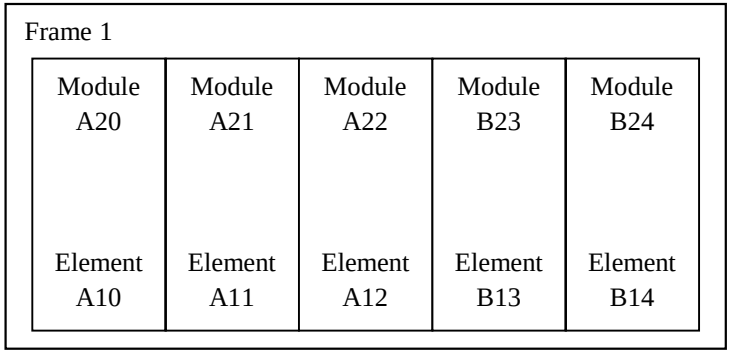
Partial Configuration:

```
ooasp_configuration("v1","c1").
ooasp_isa("c1","ElementA",10..12).
ooasp_isa("c1","ElementB",13..14).
ooasp_domain("c1","Frame",1).
ooasp_domain("c1","Element",10..14).
ooasp_domain("c1","Module",20..29).
```



Solving Object-oriented Configuration Scenarios with ASP
Scenario Reconcile a Configuration

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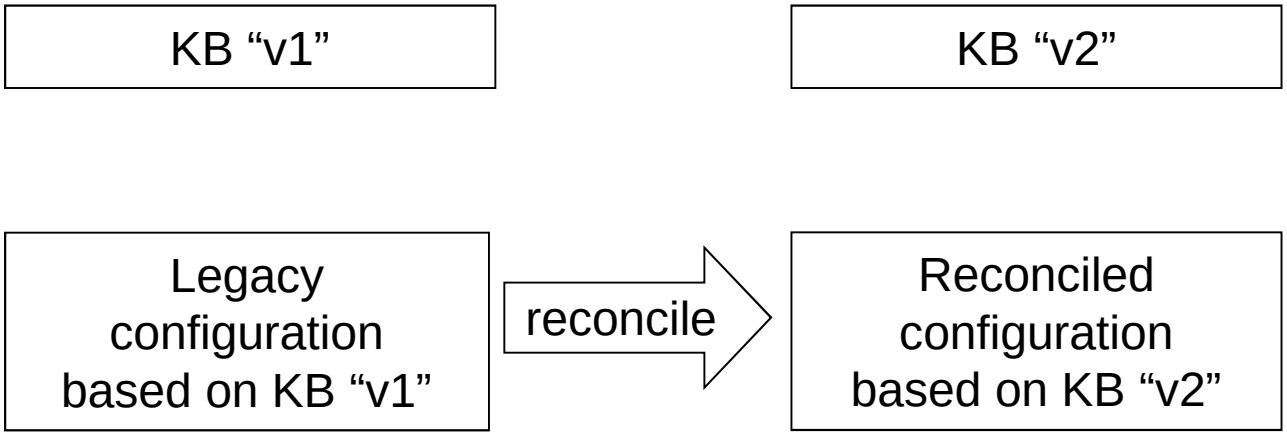
Reconcile a configuration:

Given a complete legacy configuration and the changed knowledge base which makes the configuration invalid, find a new valid configuration that is close to the legacy configuration.




```
% example reconcile rule for association
1{ooasp_associated(TARGET,A,ID1,ID2),
  ooasp_remove_associated(TARGET,A,ID1,ID2)}1 :-
        ooasp_associated(SOURCE,A,ID1,ID2),
        ooasp_reconcile(SOURCE,TARGET).
```

Solving Object-oriented Configuration Scenarios with ASP Scenario Reconcile a Configuration

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Reconcile Example:
Suppose there is an overheating problem, if two modules of type A are put next to each other.
Solution: New KB “v2” with additional constraint that disallows putting two modules of type A next to each other.

```
%  do not put 2 modules of type moduleA  next to each other
ooasp_cv(CONF,moduleANextToOther(M1,M2,P1,P2)):-
  ooasp_configuration("v2",CONF),
  ooasp_associated(CONF,"Frame_modules",F,M1),
  ooasp_associated(CONF,"Frame_modules",F,M2),
  ooasp_attribute_value(CONF,"position",M1,P1),
  ooasp_attribute_value(CONF,"position",M2,P2),
  M1!=M2,
  ooasp_isa(CONF,"ModuleA",M1),
  ooasp_isa(CONF,"ModuleA",M2),
  P2=P1+1.
```

Solving Object-oriented Configuration Scenarios with ASP
Scenario Reconcile a Configuration

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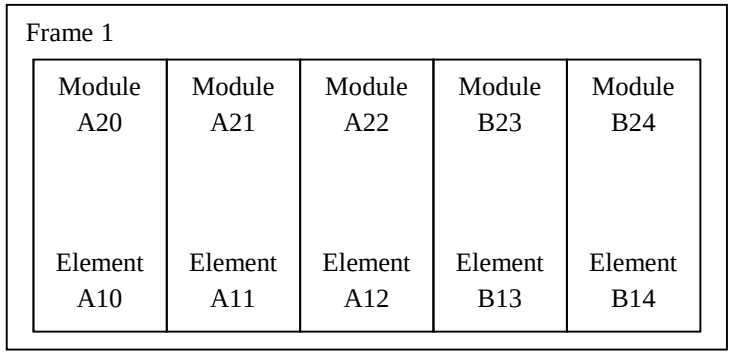
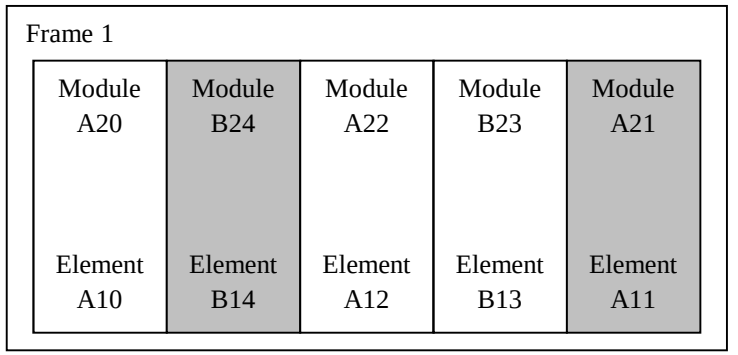
```
% Reconciled configuration “c2”
ooasp_isa("c2",“Frame",1).
ooasp_isa("c2","ElementA",10..12).
ooasp_isa("c2","ElementB",13..14).
ooasp_isa("c2",“ModuleA",20..22).
ooasp_isa("c2",“ModuleB",23..24).
ooasp_associated("c2","Frame_modules",1,10).
ooasp_associated("c2","Frame_modules",1,11).
ooasp_associated("c2","Frame_modules",1,12).
ooasp_associated("c2","Frame_modules",1,13).
ooasp_associated("c2","Frame_modules",1,14).
ooasp_attribute_value("c2","position",10,1).
ooasp_attribute_value("c2","position",12,3).
ooasp_attribute_value("c2","position",13,4).
% change
% 2 -> 5
ooasp_attribute_value("c2","position",11,5).
% 5 -> 2
ooasp_attribute_value("c2","position",14,2).
```

Legacy configuration



Reconciled configuration



Solving Object-oriented Configuration Scenarios with ASP Scenario Choosing the best Knowledge Base

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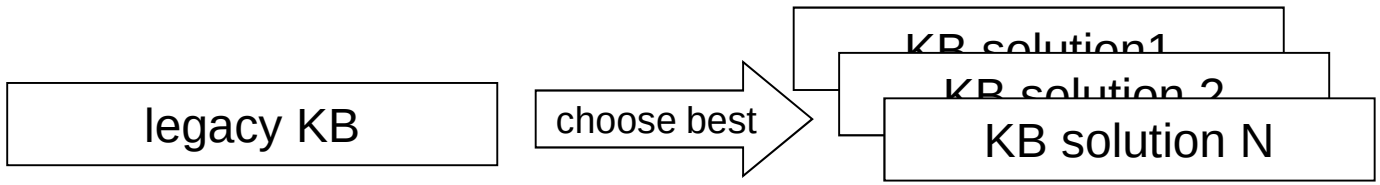
Given a new technical requirement and N knowledge bases satisfying that requirement, choose the knowledge base that minimizes the costs for reconciling legacy configurations and the estimated costs for building new systems and maintaining existing systems.

A framework like OOASP (or similar formal configuration model) helps to choose the best knowledge base.



Solving Object-oriented Configuration Scenarios with Scenario Choosing the best Knowledge Base

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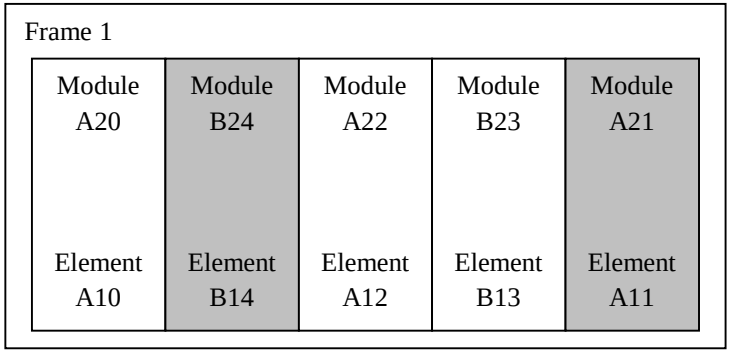
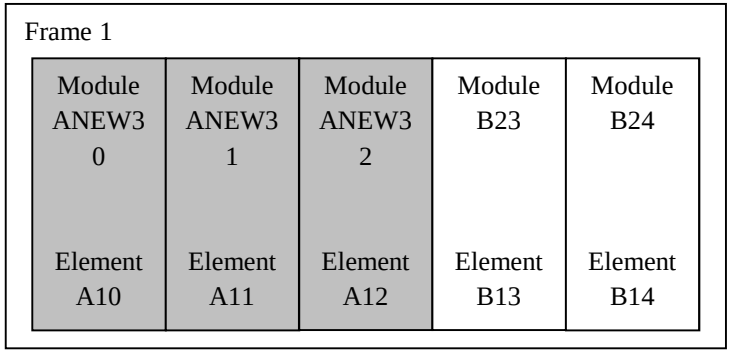
Example:
Suppose there is an alternative technical solution replacing module A with a new module ANEW, which does not have the overheating problem.
What is the best knowledge base?

- Use check scenario to find affected legacy configurations
- Use complete scenario to compute cost for building new systems with the new KB
- Use reconcile scenario to compute cost for upgrade of legacy configurations

Solution with legacy module



Solution with new module



Solving Object-oriented Configuration Scenarios with ASP Discussion

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OOASP Future:
What do we need to improve, so we can use it in our real-world projects?

- Instantiation
  - Automatically derive upper and lower bounds for instantiation
- Performance
  - Domain specific heuristics
  - Symmetry breaking
  - Avoid explosion of grounding (use constraint variables?)
  - ...

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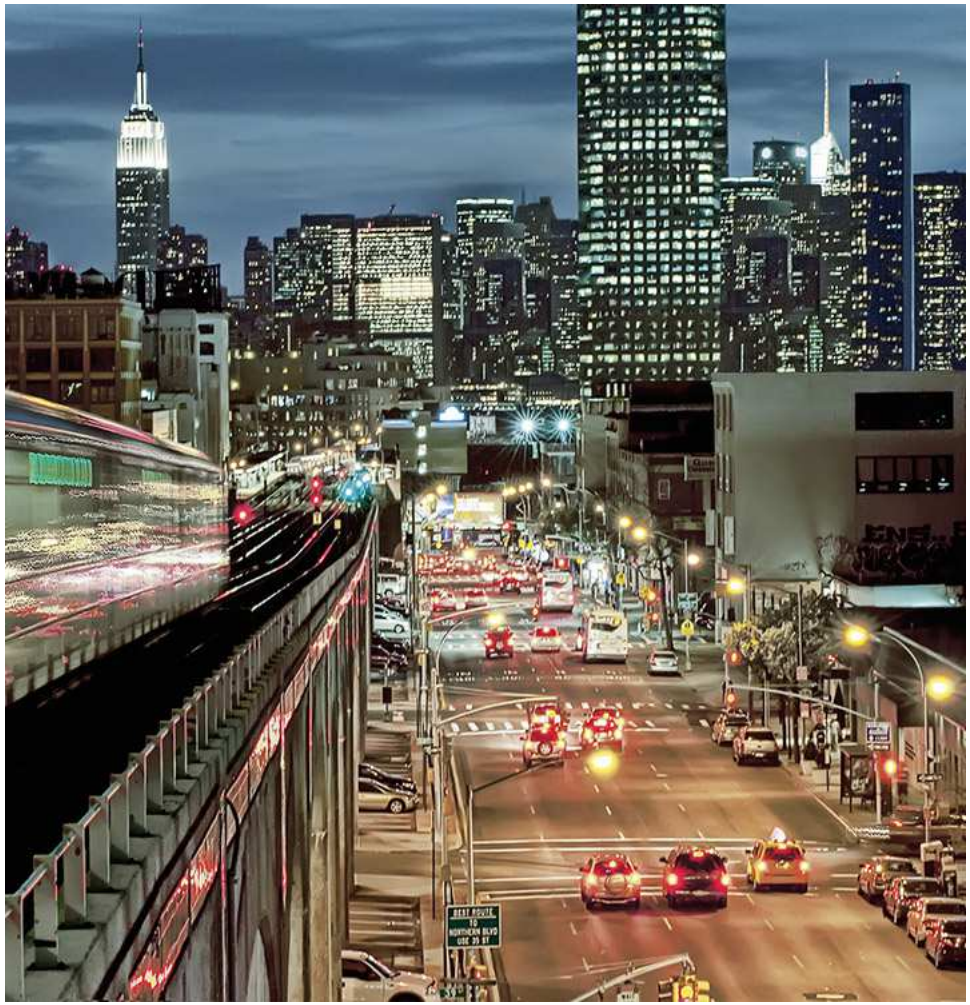

Thank you for your attention!

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