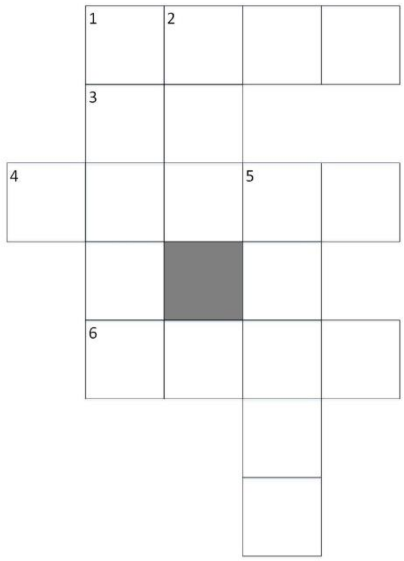
3346 Assignment 2

Zaid Albirawi

1. Consider the crossword puzzle shown. The available words that can used are



at, eta, be, hat, he, her, it , him , on, one, desk, dance, usage, easy, dove, first, else, loses, fuels, help ,haste, given, kind, sense, soon, sound, this , think.

   a. Given the representations with nodes for the positions (1-across, 2-down, etc.) and words for the domains, specify the network after domain consistency and arc consistency have halted.

      Variables: {1-across, 1-down, 2-down, 3-across, 4-across, 5-down, 6-across}

      $D_{1\text{-across}} = D_{1\text{-down}} = D_{2\text{-down}} = D_{3\text{-across}} = D_{4\text{-across}} = D_{5\text{-down}} = D_{6\text{-across}}$ = { at, eta, be, hat, he, her, it , him , on, one, desk, dance, usage, easy, dove, first, else, loses, fuels, help ,haste, given, kind, sense, soon, sound, this , think}

      Constraints = { 1-across[0] = 1-down[0]
      1-across[1] = 2-down[0]
      1-down[1] = 3-across[0]
      2-down[1] = 3-across[1]
      1-down[2] = 4-across[1]
      2-down[2] = 4-across[2]
      4-across[3] = 5-down[0]
      1-down[4] = 6-across[0]
      5-down[2] = 6-across[2] }.

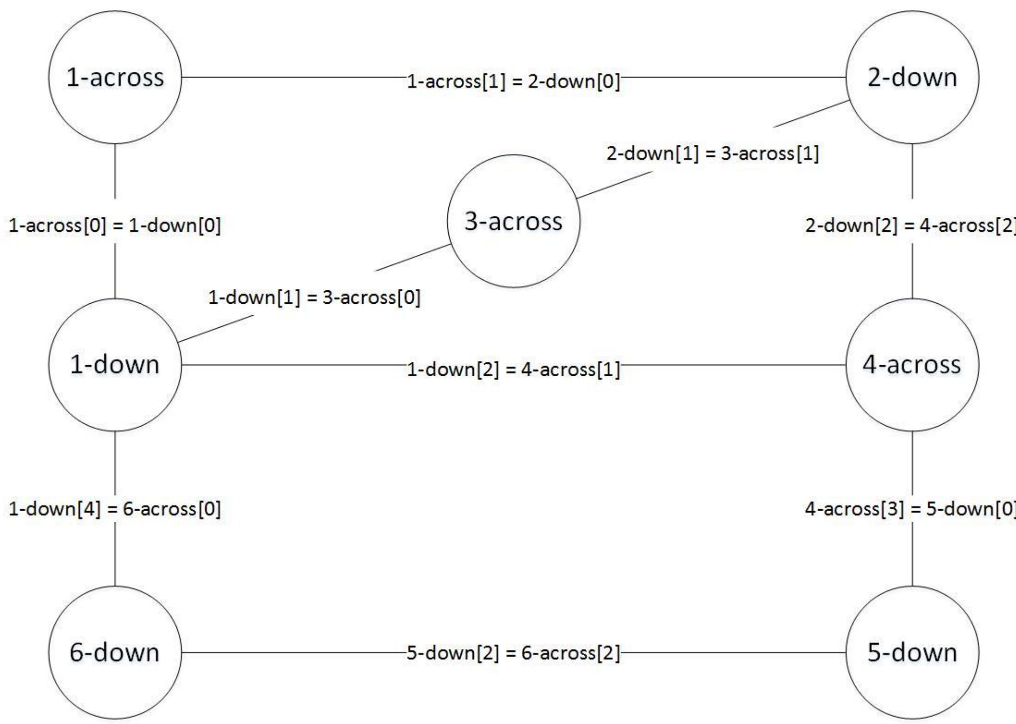
After domain consistency

$D_{1\text{-across}}$ = {desk, easy, dove, else, help, kind, soon, this}
$D_{1\text{-down}}$ = {dance, usage, first, loses, fuels, haste, given, sense, sound, think}
$D_{2\text{-down}}$ = {eta, hat, her, him, one}
$D_{3\text{-across}}$ = {at, be, he, it, on}
$D_{4\text{-across}}$ = {dance, usage, first, loses, fuels, haste, given, sense, sound, think}
$D_{5\text{-down}}$ = {dance, usage, first, loses, fuels, haste, given, sense, sound, think}
$D_{6\text{-across}}$ = {desk, easy, dove, else, help, kind, soon, this}

After arc consistency

$D_{1\text{-across}}$ = {help, soon, this}
$D_{1\text{-down}}$ = {haste, sound, think}
$D_{2\text{-down}}$ = {eta, her, one}
$D_{3\text{-across}}$ = {at, he, on}
$D_{4\text{-across}}$ = {first, fuels, usage}
$D_{5\text{-down}}$ = {given, loses, sense}
$D_{6\text{-across}}$ = {desk, dove, easy, else, kind}

Domain-consistent constraint network:



b. Consider the dual representation, in which the squares on the intersection of words are the variables and their domains are the letters that could go in these positions. Give the domain after this network has made arc consistent. Does the result after arc consistency in this representation correspond to the result in part (a)?

Variables: {1A1D, 1A2D, 1D3A, 2D3A, 1D4A, 2D4A, 4A5D, 1D6A, 5D6A}

$D_{1A1D} = D_{1A2D} = D_{1D3A} = D_{2D3A} = D_{1D4A} = D_{2D4A} = D_{4A5D} = D_{1D6A} = D_{5D6A}$ = {a, b, c, d, e, f, g, h, i, k, l, m, n, o, p, r, s, t, u, v, y}

Constraints = { |1-across| = 4
|1-down| = 5
|2-down| = 3
|3-across| = 2
|4-across| = 5
|5-down| = 5
|6-across| = 4 }.

After domain consistency

D_{1A1D} = {d, e, f, h, o, s, t}
D_{1A2D} = {a, e, h, i, l, o, s, t, u}
D_{1D3A} = {a, e, h, i, l, o, s, t, u}
D_{2D3A} = {a, e, h, i, n, o, t}
D_{1D4A} = {a, e, i, l, n, o, s, t, u}
D_{2D4A} = {a, e, i, n, r, s, v}
D_{4A5D} = {d, e, g, i, k, l, o, s, t}
D_{1D6A} = {a, d, e, k, s, t}
D_{5D6A} = {a, e, i, n, r, s, v}

After arc consistency

D_{1A1D} = {h, s, t}
D_{1A2D} = {e, h, o}
D_{1D3A} = {a, h, o}
D_{2D3A} = {e, n, t}
D_{1D4A} = {s, i, u}
D_{2D4A} = {a, e, r}
D_{4A5D} = {g, l, s}
D_{1D6A} = {d, e, k}
D_{5D6A} = {v, n, s}

The results is consistent with the one from part a.

c. Show how the variable elimination can be used to solve the crossword problem. Start from the arc-consistency network from part (a)?

Start by eliminating 1D

1D	1A	3A	4A	6A
haste	help	at	Usage	Easy
haste	help	at	Usage	else
sound	soon	on	fuels	desk
sound	soon	on	fuels	dove
think	this	he	first	kind

Eliminate 4A

1A	3A	4A	6A	2D	5D
~~help~~	~~at~~	~~usage~~	~~easy~~	~~eta~~	
~~help~~	~~at~~	~~usage~~	~~else~~	~~eta~~	
soon	on	fuels	desk	one	loses
~~soon~~	~~on~~	~~fuels~~	~~dove~~	~~one~~	
this	he	first	kind	her	sense

Solutions:

1A	3A	4A	6A	2D	5D
soon	on	fuels	desk	one	loses
this	he	first	kind	her	sense

No need for further eliminations as there are no more eliminations possible.

d. Does a different elimination ordering affect the efficiency? Explain.

Yes, if you eliminate the nodes that are connected to the maximum number of other nodes, then the operation of obtaining the solution is more efficient.

2. You are given the following knowledge base:

$a \leftarrow b \wedge c.$
$a \leftarrow e \wedge f.$
$b \leftarrow d.$
$b \leftarrow f \wedge h.$
$c \leftarrow e.$
$d \leftarrow h.$
$e.$
$f \leftarrow g.$
$g \leftarrow c.$

   a. Give a model of the knowledge base.

      $e = 1, c = 1, g = 1, f = 1, a = 1, b = 0, d = 0, h = 0.$

   b. Give an interpretation that is not model of the knowledge base.

      $e = 0, c = 1, g = 1, f = 1, a = 1, b = 0, d = 0, h = 0.$

   c. Give two atoms that are logical consequences of the knowledge base.

      e, c

   d. Give two atoms that are not logical consequences of the knowledge base.

      b, d

3. You are given the knowledge base *KB* containing the following clauses:

$a \leftarrow b \wedge c.$
$b \leftarrow d.$
$b \leftarrow e.$
$c.$
$d \leftarrow h.$
$e.$
$f \leftarrow g \wedge b.$
$g \leftarrow c \wedge k.$
$j \leftarrow a \wedge b.$

a. Show how the bottom-up proof procedure works for this example. Give all logical consequences of *KB*.

$\{\}$	Initial state
$\{e\}$	from: e.
$\{e, c\}$	from: c.
$\{e, c, b\}$	from: $b \leftarrow e$.
$\{e, c, b, a\}$	from: $a \leftarrow b \wedge c$.
$\{e, c, b, a, j\}$	from: $j \leftarrow a \wedge b$.

The logical consequences are e, c, b, a, j.

b. f is not a logical consequence of *KB*. Give a model of *KB* in which f is false.

$$e = 1, c = 1, b = 1, a = 1, j = 1, g = 0, f = 0, h = 0, d = 0, k = 0$$

c. a is a logical consequence of *KB*. Give a top-down derivation for the query ask a.

$yes \leftarrow a$
$yes \leftarrow b \wedge c$
$yes \leftarrow b$
$yes \leftarrow e$
$yes \leftarrow$

4. Consider the following knowledge base and assumables aimed to explain why people are acting suspiciously:

$goto\_forest \leftarrow walking.$
$get\_gun \leftarrow hunting.$
$goto\_forest \leftarrow hunting.$
$get\_gun \leftarrow robbing.$
$goto\_bank \leftarrow robbing.$
$goto\_bank \leftarrow banking.$
$fill\_wthdrawal\_form \leftarrow banking.$
$false \leftarrow banking \wedge robbing.$
$false \leftarrow wearing\_good\_shoes \wedge goto\_forest.$
assumable $walking, hunting, robbing, banking.$

a. Suppose get_gun is observed. What are all of the minimal explanations for this observation?

   $robbing$
   $hunting$

b. Suppose $get\_gun \wedge goto\_bank$ is observed. What are all of the minimal explanations for this observation?

   $robbing$
   $hunting \wedge banking$

c. Is there something that could be observed to remove one of these as a minimal explanation for this observation? What must be added to be able to explain this?

   Add $fill\_wthdrawal\_form$
   $get\_gun \wedge goto\_bank \wedge fill\_wthdrawal\_form$

d. What are the minimal explanations for $goto\_bank$?

   $robbing$
   $banking$

e. What are the minimal explanations for $goto\_bank \wedge get\_gun \wedge fill\_withdrawal\_form$?

   $hunting \wedge banking$

5. Consider the following clauses and integrity constraints:

   $false \leftarrow a \wedge b.$
   $false \leftarrow c.$
   $a \leftarrow d.$
   $a \leftarrow e.$
   $b \leftarrow d.$
   $b \leftarrow g.$
   $b \leftarrow h.$
   $c \leftarrow h.$

   Suppose the assumables are $\{d, e, f, g, h, i\}$. What are the minimal conflicts?

Initial set $C =< d,\{d\} >,< e,\{e\} >,< f,\{f\} >,< g,\{g\} >,< h,\{h\} >,< i,\{i\} >$.

Select $a \leftarrow d$. $C = C \cup < a,\{d\} >$
Select $a \leftarrow e$. $C = C \cup < a,\{d\} >,< a,\{e\} >$
Select $b \leftarrow d$. $C = C \cup < a,\{d\} >,< a,\{e\} >,< b,\{d\} >$
Select $b \leftarrow g$. $C = C \cup < a,\{d\} >,< a,\{e\} >,< b,\{d\} >,< b,\{g\} >$
Select $b \leftarrow h$. $C = C \cup < a,\{d\} >,< a,\{e\} >,< b,\{d\} >,< b,\{g\} >,< b,\{h\} >$
Select $c \leftarrow h$. $C = C \cup < a,\{d\} >,< a,\{e\} >,< b,\{d\} >,< b,\{g\} >,< b,\{h\} >,< c,\{h\} >$

$C =< d,\{d\} >,< e,\{e\} >,< f,\{f\} >,< g,\{g\} >,< h,\{h\} >,< i,\{i\} >,< a,\{d\} >,< a,\{e\} >$
$,< b,\{d\} >,< b,\{g\} >,< b,\{h\} >,< c,\{h\} >$.

Select $\perp \leftarrow a \wedge b$ using, $< a,\{d\} >,< b,\{d\} >. C = C \cup <\perp,\{d\} >$
Select $\perp \leftarrow a \wedge b$ using, $< a,\{d\} >,< b,\{g\} >. C = C \cup <\perp,\{d,g\} >$
Select $\perp \leftarrow a \wedge b$ using, $< a,\{d\} >,< b,\{h\} >. C = C \cup <\perp,\{d,h\} >$
Select $\perp \leftarrow a \wedge b$ using, $< a,\{e\} >,< b,\{d\} >. C = C \cup <\perp,\{e,d\} >$
Select $\perp \leftarrow a \wedge b$ using, $< a,\{e\} >,< b,\{g\} >. C = C \cup <\perp,\{e,g\} >$
Select $\perp \leftarrow a \wedge b$ using, $< a,\{e\} >,< b,\{h\} >. C = C \cup <\perp,\{e,h\} >$
Select $\perp \leftarrow c$ using, $< c,\{h\} >. C = C \cup <\perp,\{ h\} >$

Therefore, $C =< d,\{d\} >,< e,\{e\} >,< f,\{f\} >,< g,\{g\} >,< h,\{h\} >,< i,\{i\} >,< a,\{d\} >$
$,< a,\{e\} >,< b,\{d\} >,< b,\{g\} >,< b,\{h\} >,< c,\{h\},<\perp,\{d\} >,<\perp,\{d,g\} >,<\perp,\{d,h\} >,<$
$\perp,\{e,d\} >,<\perp,\{e,g\} >,<\perp,\{e,h\} >,<\perp,\{ h\} >$.

Hence, the minimal conflict sets are, $\big\{\{d\},\{e,g\},\{h\}\big\}$.