Q1:

1. a sandwich pickled every pickle in every pickle .

2. every perplexed perplexed chief of staff under every chief of staff on every sandwich with the delicious floor in every pickle with a delicious sandwich pickled a sandwich with every chief of staff under every pickle under the sandwich on a sandwich under a president under every pickle with every floor on every president with a sandwich on a sandwich on the delicious fine president with every perplexed pickled floor .

3. a chief of staff understood the delicious sandwich with every floor !

4. the pickle ate every fine pickle !

5. is it true that every floor pickled a pickle with every chief of staff ?

6. is it true that a chief of staff pickled a pickle on a floor on a president in every fine sandwich with a perplexed floor on every president with every delicious chief of staff with a sandwich with the president on a sandwich on every floor under every sandwich with a chief of staff on a chief of staff on every president under the floor on the floor in the pickle on the sandwich with a floor under the sandwich in a floor on every chief of staff in a president under a chief of staff in a sandwich in the floor on every sandwich in every chief of staff with every president in a pickle on the floor in a floor under the pickle in the sandwich under a chief of staff with every sandwich with the chief of staff with a pickle on every delicious president with a president under every president under the sandwich under the president with the sandwich in a pickle in the floor with every floor on the floor in the floor on every sandwich with the chief of staff under every president in the floor with a floor in every sandwich with every delicious sandwich under the president with every pickle on a president on the president under every president under every president under every fine pickle in every pickled pickle on a delicious chief of staff in the floor under every fine sandwich with the sandwich with the pickle in every pickle on the perplexed floor under a chief of staff with a chief of staff with the chief of staff with a pickle with a president with the pickle on a chief of staff under the chief of staff with the president under the sandwich in the sandwich ?

7. a sandwich under a sandwich under a president under the president with a fine floor under every chief of staff on a chief of staff kissed the pickle !

8. is it true that every floor ate a president ?

9. is it true that the pickle in the president in a president in the sandwich under the floor on every floor under the sandwich under a pickle on a president in every chief of staff with a president under the sandwich in the perplexed floor with every floor on the chief of staff in a president with the president in a floor on the sandwich on every pickle in a floor under a sandwich in the pickle with every president under every pickle with the sandwich with a chief of staff with the pickle with the floor in the sandwich in the chief of staff with the president on the sandwich under the president under a floor under every pickle under a chief of staff on a chief of staff in the pickle with every pickle under every pickle with every fine president with a chief of staff under every pickle in the floor on a pickle on a president in the pickle with every pickle in a pickle under every sandwich under every pickle under every floor with a sandwich on the fine president under the pickle under every sandwich in every chief of staff in a pickled chief of staff in the sandwich in every sandwich in a floor in the chief of staff on every floor with every floor on a chief of staff in a floor on a chief of staff in every pickle with a perplexed president with every sandwich under the fine perplexed chief of staff on the delicious sandwich in every sandwich on the chief of staff in every floor with a floor under

every delicious pickle under the pickle under the chief of staff under the chief of staff on a president in a delicious pickle pickled every delicious president ?

10. is it true that every floor with every pickle ate every floor under a president ?

Q2:

a) Cause there is a loop in the grammar given and there Is a large chance to get into the loop again and again. As a result, the program generated long sentences.
The responsible grammars are:

1   NP   NP PP
1   PP   Prep NP
1   Noun   Adj Noun

All these grammars have self-loops or loop with others. eg. NP may generate PP and PP may generate NP, this is a loop

b) Because of the probability to generate multiple adjectives is low. For example, we have a Noun. Then the probability to generate 1 adjective is 1/6, the probability of generating 2 adjectives are 1/(6 * 6) = 1/36 ⋯..therefore there is small chance to generate multiple adjectives.

c) See the program

d) By increase the weight of

1   Noun   Adj Noun to 10 Noun   Adj Noun

and decrease the weight of

1   NP   NP PP to 0.1 NP   NP PP
1   PP   Prep NP to 0.1 PP Prep NP

The result becomes much shorter with more like:

the fine floor understood every sandwich .
a pickled floor wanted every delicious delicious pickle !
the perplexed pickle on the delicious fine pickled delicious delicious delicious fine perplexed pickle understood the fine fine chief of staff .
the floor understood a fine president !
a fine perplexed chief of staff wanted the pickled sandwich under the perplexed fine chief of staff .
every fine perplexed president kissed the delicious perplexed fine chief of staff !
every pickled pickled fine floor kissed every perplexed perplexed perplexed chief of staff !
every floor kissed the president !
a fine delicious pickled fine sandwich kissed the fine delicious floor .
every fine fine fine chief of staff wanted every sandwich.

e) See the program

a president kissed the pickle !
is it true that a pickle with the floor kissed every sandwich with a floor with a floor ?
is it true that every floor wanted the floor ?
is it true that every president ate a president on a chief of staff ?
every pickle ate every pickle with a floor with a president on a sandwich with the president with a chief of staff !
is it true that every chief of staff kissed every pickle with a chief of staff ?
is it true that every delicious floor wanted every president ?
is it true that a sandwich ate the chief of staff with a delicious pickled fine chief of staff with every pickle on the president on every delicious pickle with the delicious pickle with a floor on the floor in the chief of staff in every president with the pickle with every delicious perplexed president ?

every pickle pickled every pickle !

the president with every perplexed chief of staff with every floor understood the chief of staff !

Q3.

1.modification

Discussion:

This modification handles the following problems:

---Add a new type of preterminal: Pnoun stands for proper noun like "Sally","America", since this type of noun doesn't have a determiner in front. And add a grammar rule "NP = Pnoun" 3(a)

---Add a new type of preterminal: Conj stands for conjunction to connect two verbs or nouns. 3(b)

---Add a new type of preterminal: Vi stands for intransitive verb. 3(c)

---Add a new type of preterminal: Pr stands for pronoun, it's mainly used in clause under current situations, and just have a value "that" right now. 3(d)

---Add two new rules for creating full sentences. Dealing with subject clause sentences like 3(e) and 3(f), these two sentence express the similar meaning but write in different order of words.

---Add grammar rules like "Noun = Adj + Noun" and "Adj = Adv + Adj", they work in a similar way to let a noun has several adjectives in front and let those adjectives also have several adverb embellish. 3(g)

---Add a grammar rule that "VP = Vi PP" : sometimes, intransitive verb can be followed by preposition phrase to have noun phrase behind.

2. sentences

Sally under Sally or every sandwich with every chief of staff or every proposal in every proposal or the very perplexed president or Sally or Sally or Sally and a floor with every chief of staff and Sally or Sally and Sally with a chief of staff and every president on Sally kissed that the president and Sally and Sally or a proposal and every delicious pickle with Sally under Sally with Sally with a president on Sally under the floor or every sandwich and Sally in the pickle with a chief of staff under every proposal under Sally with the floor in Sally under Sally or Sally or Sally and Sally and the pickle under the proposal and the perplexed floor in the proposal and every president on Sally in every floor on Sally on every pickle with Sally under Sally and Sally or a floor and Sally with Sally or the pickle or a desk with Sally in Sally and every sandwich in Sally and Sally and a president and Sally and Sally or the sandwich and Sally and Sally on Sally or every president under Sally and a president on Sally under every sandwich on every floor with Sally on Sally under Sally on a pickled chief of staff and every very perplexed pickle kissed that a floor pickled that Sally with Sally under a chief of staff and Sally worked .

is it true that every pickle in every floor or Sally on the floor and Sally on a chief of staff or Sally and Sally or Sally under the desk under the chief of staff in the president and a proposal sighed and worked ?

is it true that the sandwich or Sally perplexed or wanted a president or the pickle ?

it pickled every president that the sandwich understood every desk .

that the sandwich and Sally or Sally and every sandwich on Sally and Sally in a president with

a president with the perplexed proposal on Sally or Sally and every proposal or the chief of staff or Sally and Sally and Sally and Sally or Sally and Sally or Sally or a desk or Sally or a desk under Sally or Sally and Sally and Sally in a floor in Sally on Sally in the very pickled proposal and the fine chief of staff in the floor and every pickle or the proposal or Sally and Sally in a president and a pickle under Sally and Sally and Sally and Sally or every floor and the desk and Sally under Sally or the delicious sandwich and a fine floor or the floor or Sally with Sally under every delicious chief of staff in Sally under a president and Sally in Sally under Sally with the desk in Sally and the chief of staff and a president or Sally and a fine desk under Sally on Sally and the floor and Sally under Sally in every sandwich under the floor in the proposal or a president or the proposal in the floor and the perplexed chief of staff and Sally or the floor under a sandwich in the chief of staff on a floor with Sally with Sally and every president … .

a floor perplexed or wanted and thought that Sally in Sally or Sally under Sally or Sally sighed .

a floor and Sally under Sally understood that every proposal sighed .

it sighed with Sally and Sally or Sally or the sandwich on the pickle and Sally with the president and a proposal and Sally or Sally or the desk under a president or the very fine floor or Sally under Sally in Sally with a proposal with Sally with Sally and every proposal or the desk and a desk and the perplexed chief of staff on a floor and Sally under Sally in every president or a proposal under a floor and Sally and a floor in Sally in a floor on every sandwich or Sally on the floor that Sally pickled that Sally and the president or the proposal with every pickled chief of staff and Sally in a fine president under Sally or Sally in Sally under Sally in every president and the proposal and a president or Sally or Sally under the delicious chief of staff or Sally and a desk or Sally in Sally under Sally or Sally and the pickle under Sally under a desk and every floor with the desk or Sally or Sally in the president under Sally and Sally on Sally in the president and every chief of staff and a pickle with Sally with every chief of staff or the president under every proposal under every president in a pickle or Sally understood Sally and the sandwich and Sally in a sandwich or Sally .

is it true that every very pickled chief of staff sighed with Sally ?

it wanted Sally or Sally on every perplexed pickle on Sally under a president and every desk and a proposal or the chief of staff on every sandwich with the floor under every floor and Sally on Sally and the chief of staff or Sally and Sally and Sally under Sally and Sally or Sally or a pickle in Sally under Sally on Sally with Sally in Sally with a pickle on the sandwich and Sally or the sandwich on a floor on Sally under Sally on Sally on Sally on every pickled sandwich or a sandwich on Sally on Sally and Sally with a proposal on the proposal on a proposal or every proposal under Sally with the perplexed president in Sally and Sally or Sally in the sandwich in Sally and every desk or Sally on Sally and Sally with the proposal in every desk and a pickle and every chief of staff under Sally with Sally and Sally with every sandwich or the sandwich under the very very delicious sandwich or Sally under a pickle under the floor or Sally and every delicious desk and Sally or Sally on Sally or a fine pickle on the chief of staff on a sandwich in the perplexed pickle and the proposal and the fine president on every pickle

or Sally or the sandwich and … … … … … … … … … … … … … … … … … … that … .

Q4.
1.(ROOT (S (NP (NP (NP (NP (NP (Pnoun Sally))
                         (Conj or)
                         (NP (NP (Pnoun Sally))
                             (Conj and)
                             (NP (NP (NP (NP (Pnoun Sally))
                                         (Conj and)
                                         (NP (Pnoun Sally)))
                                     (PP (Prep in)
                                         (NP (Pnoun Sally))))
                                 (PP (Prep on)
                                     (NP (Pnoun Sally))))))
                     (PP (Prep in)
                         (NP (Pnoun Sally))))
                 (PP (Prep with)
                     (NP (Pnoun Sally))))
             (Conj or)
             (NP (NP (NP (Pnoun Sally))
                     (PP (Prep with)
                         (NP (Det a)
                             (Noun (Adj delicious)
                                   (Noun president)))))
                 (PP (Prep with)
                     (NP (NP (NP (Det the)
                                 (Noun floor))
                             (Conj or)
                             (NP (NP (Det the)
                                     (Noun chief
                                           of
                                           staff))
                                 (Conj and)
                                 (NP (NP (NP (NP (Pnoun Sally))
                                             (PP (Prep in)
                                                 (NP (Pnoun Sally))))
                                         (Conj or)
                                         (NP (NP (NP (NP (Pnoun Sally))
                                                     (PP (Prep with)
                                                         (NP (Det every)
                                                             (Noun president))))
                                                 (PP (Prep with)
                                                     (NP (NP (NP (NP (Det every)
                                                                     (Noun floor))
                                                                 (Conj and)
                                                                 (NP (NP (Det a)
                                                                         (Noun

floor))

                                                                     (PP   (Prep

```
under)
                                                                (NP    (Det
the)
                                                                    (Noun
pickle)))))
                                            (Conj and)
                                            (NP (NP (Det the)
                                                    (Noun floor))
                                                (Conj or)
                                                (NP         (Pnoun
Sally))))
                                        (PP (Prep under)
                                            (NP (Det a)
                                                (Noun        (Adj
delicious)
                                                      (Noun
sandwich)))))))
                                (PP (Prep in)
                                    (NP (NP (Pnoun Sally))
                                        (Conj or)
                                        (NP (NP (Pnoun Sally))
                                            (Conj and)
                                            (NP (Det every)
                                                (Noun
president)))))))
                            (Conj and)
                            (NP (Pnoun Sally)))))
                (Conj and)
                (NP (NP (NP (Pnoun Sally))
                        (PP (Prep on)
                            (NP (NP (Det a)
                                    (Noun sandwich))
                                (PP (Prep with)
                                    (NP (NP (Pnoun Sally))
                                        (Conj or)
                                        (NP (NP (Pnoun Sally))
                                            (Conj or)
                                            (NP (Det the)
                                                (Noun president))))))))
                (Conj or)
                (NP (NP (NP (Pnoun Sally))
                        (Conj or)
                        (NP (NP (NP (NP (Pnoun Sally))
                                (PP (Prep under)
                                    (NP (NP (Pnoun Sally))
                                        (PP (Prep on)
                                            (NP    (NP    (NP    (Det
```

every)

               (Noun

floor))

               (Conj and)
               (NP   (Pnoun

Sally)))

               (Conj or)
               (NP (NP (Pnoun

Sally))

               (PP (Prep on)
               (NP

          (PP (Prep with)

(Pnoun Sally)))))))))
          (NP (NP (NP (NP (NP (NP (NP (Pnoun

Sally))

               (Conj or)
               (NP   (NP

(Det the)

(Noun sandwich))

               (PP

(Prep in)

(NP (NP (NP (NP (Det every)

(Noun sandwich))

(PP (Prep under)

(NP (Det the)

(Noun (Adj pickled)

(Noun sandwich)))))

(Conj and)

(NP (NP (NP (NP (Det every)

(Noun pickle))

(Conj and)

(NP (NP (NP (NP (NP (NP (NP (NP (NP (Det the)

(Noun pickle))

```
(PP (Prep with)

(NP (NP (NP (Pnoun Sally))

(Conj and)

(NP (Det the)

(Noun chief

of

staff)))

(PP (Prep in)

(NP (Pnoun Sally))))))

(Conj and)

(NP (Det the)

(Noun pickle)))

(PP (Prep with)

(NP (Pnoun Sally))))

(PP (Prep on)

(NP (Pnoun Sally))))

(PP (Prep on)

(NP (Pnoun Sally))))

(PP (Prep under)

(NP (NP (Pnoun Sally))

(PP (Prep on)

(NP (NP (NP (NP (NP (Det a)

(Noun sandwich))

(Conj and)
```

(NP (Pnoun Sally)))

(Conj or)

(NP (NP (NP (NP (Det every)

(Noun floor))

(Conj and)

(NP (NP (Pnoun Sally))

(PP (Prep under)

(NP (NP (NP (NP (NP (Det a)

(Noun sandwich))

(Conj and)

(NP (Pnoun Sally)))

(Conj or)

(NP (NP (NP (NP (NP (Pnoun Sally))

(Conj and)

(NP (NP (NP (Det a)

(Noun pickle))

(Conj or)

(NP (NP (Det a)

(Noun president))

(Conj and)

(NP (NP (Pnoun Sally))

(PP (Prep under)

(NP (NP (NP (NP (NP (NP (Det the)

(Noun floor))

(PP (Prep under)

(NP (NP (Pnoun Sally))

(PP (Prep in)

(NP (Det a)

(Noun (Adj pickled)

(Noun chief

of

staff)))))))

(PP (Prep under)

(NP (Pnoun Sally))))

(PP (Prep in)

(NP (NP (NP (Pnoun Sally))

(Conj and)

(NP (NP (NP (NP (Det every)

(Noun president))

(Conj or)

(NP (Det every)

(Noun president)))

(Conj or)

(NP (Det the)

(Noun sandwich)))

(Conj or)

(NP (NP (Det every)

(Noun (Adj perplexed)

(Noun chief

of

staff)))

(Conj and)

(NP (NP (NP (NP (NP (NP (NP (Pnoun Sally))

(Conj or)

(NP (Pnoun Sally)))

(Conj or)

(NP (NP (NP (NP (Det every)

(Noun president))

(Conj and)

(NP (NP (Det the)

(Noun floor))

(PP (Prep on)

(NP (Det every)

(Noun floor)))))

(Conj and)

(NP (NP (NP (NP (Det every)

(Noun pickle))

(PP (Prep in)

(NP (NP (Det a)

(Noun sandwich))

(Conj or)

(NP (NP (Det a)

(Noun (Adj pickled)

(Noun president)))

(Conj or)

(NP (NP (NP (Det a)

(Noun sandwich))

(Conj or)

(NP (NP (Det every)

(Noun sandwich))

(Conj and)

(NP (Det the)

(Noun (Adj fine)

(Noun ...)))))

(Conj ...)

(NP ...))))))

(Conj ...)

(NP ...))

(Conj ...)

(NP ...)))

(PP ...)))

(PP ...))

(Conj ...)

(NP ...))

```
(Conj ...)

(NP ...))

(PP ...)))))

(PP ...))))

(PP ...))

(PP ...))))))

(Conj ...)

(NP ...)))

(Conj ...)

(NP ...))

(Conj ...)

(NP ...))

(Conj ...)

(NP ...)))

(PP ...))

(Conj ...)

(NP ...)))))

(Conj ...)

(NP ...))

(PP ...)))

(PP ...))

(PP ...))))))

(PP ...))
```

```
                    (PP ...)))

                    (Conj ...)

                    (NP ...))

                    (Conj ...)

                    (NP ...)))

                    (Conj ...)

                    (NP ...))))))
                                                                    (PP ...))
                                                          (Conj ...)
                                                          (NP ...))
                                                    (PP ...))
                                              (PP ...))
                                          (PP ...))))
                                  (PP ...)))
                          (Conj ...)
                          (NP ...)))))))))
              (VP ...)
              (Pr ...)
              (S ...))
          .)

2. (ROOT (S (NP (NP (NP (Pnoun Sally))
                   (Conj or)
                   (NP (NP (NP (NP (Det a)
                                   (Noun pickle))
                               (PP (Prep under)
                                   (NP (Det every)
                                       (Noun sandwich))))
                           (Conj and)
                           (NP (NP (NP (Pnoun Sally))
                                   (PP (Prep with)
                                       (NP (Det the)
                                           (Noun (Adj (Adv very)
                                                      (Adj delicious))
                                                 (Noun president)))))
                               (Conj or)
                               (NP (NP (Pnoun Sally))
                                   (PP (Prep in)
                                       (NP (Det the)
                                           (Noun pickle))))))
               (PP (Prep on)
```

```
(NP (NP (NP (NP (NP (Det the)
                    (Noun (Adj perplexed)
                          (Noun chief
                                of
                                staff)))
            (Conj or)
            (NP (Pnoun Sally)))
        (PP (Prep in)
            (NP (NP (Pnoun Sally))
                (Conj and)
                (NP (NP (NP (Pnoun Sally))
                        (PP (Prep on)
                            (NP (NP (NP (Det every)
                                        (Noun floor))
                                    (PP (Prep on)
                                        (NP    (Pnoun
Sally))))
                                (PP (Prep with)
                                    (NP    (NP    (Pnoun
Sally))
                                        (PP       (Prep
with)
                                            (NP    (NP
(NP (Det the)

(Noun president))

(Conj or)

(NP (NP (NP (Pnoun Sally))

(Conj and)

(NP (Pnoun Sally)))

(PP (Prep on)

(NP (NP (NP (Det the)

(Noun chief

of

staff))

(PP (Prep on)
```

(NP (Det a)

(Noun president))))

(Conj or)

(NP (NP (Det every)

(Noun sandwich))

(Conj and)

(NP (Det every)

(Noun president)))))))

                    (Conj
and)

                    (NP

(NP (Pnoun Sally))

(Conj or)

(NP (Det the)

(Noun (Adj fine)

(Noun (Adj pickled)

(Noun (Adj delicious)

(Noun (Adj (Adv very)

(Adj delicious))

(Noun chief

of

staff))))))))))))))

         (Conj and)
         (NP (NP (Det a)
              (Noun sandwich))
           (Conj or)
           (NP (Pnoun Sally)))))))
      (Conj and)
      (NP (NP (NP (NP (Pnoun Sally))
           (Conj and)

```
                                          (NP (Det the)
                                              (Noun pickle)))
                                    (PP (Prep in)
                                        (NP (Pnoun Sally))))
                                (PP (Prep in)
                                    (NP (Pnoun Sally)))))
                        (Conj and)
                        (NP (Det the)
                            (Noun (Adj perplexed)
                                  (Noun sandwich)))))))))
              (PP (Prep on)
                  (NP (NP (Det a)
                          (Noun (Adj pickled)
                                (Noun floor)))
                      (PP (Prep with)
                          (NP (Pnoun Sally))))))
          (VP (Vt wanted)
              (NP (NP (Pnoun Sally))
                  (PP (Prep in)
                      (NP (Det every)
                          (Noun floor))))))
        !)

3. (ROOT is
        it
        true
        that
        (S (NP (NP (Det every)
                   (Noun (Adj (Adv very)
                              (Adj (Adv very)
                                   (Adj delicious)))
                         (Noun pickle)))
               (PP (Prep on)
                   (NP (NP (Det every)
                           (Noun (Adj delicious)
                                 (Noun (Adj delicious)
                                       (Noun chief
                                             of
                                             staff))))
                       (PP (Prep in)
                           (NP (NP (Det every)
                                   (Noun sandwich))
                               (PP (Prep with)
                                   (NP (Det the)
                                       (Noun floor)))))))))
            (VP (Vi sighed)
                (PP (Prep under)
```

```
                    (NP (Det every)
                        (Noun (Adj delicious)
                              (Noun (Adj delicious)
                                    (Noun (Adj (Adv very)
                                               (Adj pickled))
                                          (Noun pickle))))))))))
        ?)

4. (ROOT That
        (S (NP (Pnoun Sally))
           (VP (Vt wanted)
               (NP (NP (Det a)
                       (Noun chief
                             of
                             staff))
                   (Conj or)
                   (NP (NP (NP (NP (Pnoun Sally))
                               (Conj or)
                               (NP (NP (NP (NP (NP (NP (Det the)
                                                       (Noun floor))
                                                   (PP (Prep with)
                                                       (NP (NP (NP (NP (NP (Pnoun
Sally))
                                                                       (PP      (Prep
with)
                                                                           (NP
(Pnoun Sally))))
                                                                   (Conj or)
                                                                   (NP (NP (NP (NP
(NP (NP (Pnoun Sally))

(PP (Prep with)

(NP (Pnoun Sally))))

(Conj or)

(NP (NP (NP (Det the)

(Noun pickle))

(Conj or)

(NP (NP (NP (Pnoun Sally))

(PP (Prep in)
```

(NP (NP (Pnoun Sally))

(Conj or)

(NP (Pnoun Sally)))))

(Conj or)

(NP (Det every)

(Noun pickle))))

(PP (Prep with)

(NP (NP (NP (NP (Det a)

(Noun sandwich))

(PP (Prep under)

(NP (NP (NP (Det the)

(Noun sandwich))

(PP (Prep in)

(NP (NP (NP (NP (Det every)

(Noun sandwich))

(PP (Prep under)

(NP (NP (NP (NP (Pnoun Sally))

(PP (Prep on)

(NP (NP (Det the)

(Noun pickle))

(Conj and)

(NP (Det every)

(Noun floor)))))

(Conj or)

(NP (Det every)

(Noun pickle)))

(PP (Prep with)

(NP (Pnoun Sally))))))

(PP (Prep under)

(NP (NP (NP (Det the)

(Noun pickle))

(Conj or)

(NP (NP (NP (Pnoun Sally))

(PP (Prep in)

(NP (NP (NP (Det every)

(Noun pickle))

(Conj and)

(NP (Det every)

(Noun floor)))

(PP (Prep with)

(NP (NP (Det a)

(Noun sandwich))

(PP (Prep in)

(NP (NP (NP (Det every)

(Noun sandwich))

(Conj and)

(NP (Det the)

(Noun floor)))

(Conj or)

(NP (NP (Pnoun Sally))

(PP (Prep with)

(NP (Det every)

(Noun chief

of

staff))))))))))))

(Conj or)

(NP (NP (NP (NP (Det a)

(Noun chief

of

staff))

(PP (Prep on)

(NP (NP (Pnoun Sally))

(PP (Prep under)

(NP (Pnoun Sally))))))

(PP (Prep under)

(NP (Det every)

(Noun (Adj pickled)

(Noun chief

of

staff)))))

(PP (Prep with)

(NP (Det the)

(Noun floor))))))

(PP (Prep with)

(NP (NP (NP (Det a)

(Noun floor))

(PP (Prep in)

(NP (Pnoun Sally))))

(PP (Prep under)

(NP (Pnoun Sally))))))))

(PP (Prep on)

(NP (NP (Pnoun Sally))

(Conj or)

(NP (Pnoun Sally)))))))

(PP (Prep in)

(NP (NP (Pnoun Sally))

(Conj or)

(NP (Det a)

(Noun (Adj pickled)

(Noun (Adj delicious)

(Noun chief

of

staff)))))))))

(Conj or)

```
(NP (NP (Pnoun Sally))

(PP (Prep with)

(NP (Pnoun Sally)))))

(PP (Prep in)

(NP (Det the)

(Noun president)))))))
                                                                    (Conj
and)
                                                                    (NP
(NP (NP (NP (Pnoun Sally))

(PP (Prep under)

(NP (NP (Det the)

(Noun chief

of

staff))

(Conj and)

(NP (Pnoun Sally)))))

(Conj or)

(NP (NP (NP (Det every)

(Noun (Adj fine)

(Noun president)))

(PP (Prep in)

(NP (NP (Pnoun Sally))

(Conj and)

(NP (Det a)

(Noun sandwich)))))
```

```
(PP (Prep on)
(NP (Det every)
(Noun chief
of
staff)))))
(Conj or)
(NP (NP (Pnoun Sally))
(PP (Prep in)
(NP (Pnoun Sally))))))
                                                              (Conj
and)
                                                              (NP    (NP
(Pnoun Sally))
                                                                        (PP
(Prep under)
(NP (Det every)
(Noun pickle)))))
                                                            (PP      (Prep
with)
                                                              (NP
(Pnoun Sally)))))
                                                         (Conj and)
                                                         (NP (NP (Det a)
                                                                 (Noun floor))
                                                             (PP (Prep under)
                                                                 (NP  (NP  (Det
a)
                                                                            (Noun
sandwich))
                                                                    (PP  (Prep
in)
                                                                            (NP
(NP (NP (NP (NP (Pnoun Sally))
(PP (Prep on)
```

(NP (Pnoun Sally))))

(PP (Prep under)

(NP (Pnoun Sally))))

(PP (Prep under)

(NP (NP (NP (Pnoun Sally))

(Conj and)

(NP (NP (Pnoun Sally))

(PP (Prep with)

(NP (Pnoun Sally)))))

(Conj or)

(NP (Pnoun Sally)))))

(PP (Prep with)

(NP (NP (Det the)

(Noun pickle))

(Conj and)

(NP (Pnoun Sally))))))))))

sandwich))

Sally)))

president)))))))

(Conj or)
(NP (NP (NP (Det every)
            (Noun

        (Conj or)
        (NP   (Pnoun

    (Conj and)
    (NP (NP (Det a)
            (Noun floor))
        (Conj and)
        (NP (Det every)
            (Noun

(PP (Prep under)
    (NP (Pnoun Sally))))

```
                                        (PP (Prep with)
                                            (NP (Pnoun Sally))))
                                 (PP (Prep on)
                                     (NP (NP (Det the)
                                             (Noun floor))
                                         (Conj or)
                                         (NP (Pnoun Sally)))))
                           (PP (Prep on)
                               (NP (Pnoun Sally)))))
                      (PP (Prep in)
                          (NP (Pnoun Sally))))
                  (PP (Prep with)
                      (NP (NP (Pnoun Sally))
                          (PP (Prep under)
                              (NP (NP (Det the)
                                      (Noun floor))
                                  (Conj or)
                                  (NP (NP (Det a)
                                          (Noun president))
                                      (PP (Prep on)
                                          (NP (NP (Det every)
                                                  (Noun pickle))
                                              (PP (Prep under)
                                                  (NP (Det a)
                                                      (Noun (Adj perplexed)
                                                            (Noun
president)))))))))))))))))))))
        (VP (Vi worked)))

5. (ROOT That
        (S (NP (NP (Det a)
                   (Noun sandwich))
               (Conj and)
               (NP (NP (NP (Pnoun Sally))
                       (Conj or)
                       (NP (NP (Det a)
                               (Noun (Adj (Adv very)
                                          (Adj perplexed))
                                     (Noun pickle)))
                          (Conj and)
                          (NP (NP (Det the)
                                  (Noun floor))
                              (PP (Prep on)
                                  (NP (NP (Det the)
                                          (Noun floor))
                                      (Conj or)
                                      (NP (Pnoun Sally)))))))))
```

```
                (PP (Prep on)
                    (NP (NP (Det a)
                            (Noun floor))
                        (Conj and)
                        (NP (Det the)
                            (Noun pickle))))))))
        (VP (Vi worked)
            (PP (Prep in)
                (NP (NP (NP (NP (Pnoun Sally))
                            (PP (Prep under)
                                (NP (Det a)
                                    (Noun sandwich))))
                        (PP (Prep in)
                            (NP (Pnoun Sally))))
                    (Conj or)
                    (NP (Pnoun Sally)))))))
        (Pr that)
        (S (NP (NP (NP (NP (Det every)
                           (Noun floor))
                       (Conj and)
                       (NP (Pnoun Sally)))
                   (PP (Prep on)
                       (NP (Det the)
                           (Noun chief
                                 of
                                 staff))))
               (Conj and)
               (NP (NP (Det the)
                       (Noun sandwich))
                   (Conj or)
                   (NP (Det the)
                       (Noun president))))
           (VP (Vi (Vi (Vi (Vi worked)
                           (Conj or)
                           (Vi worked))
                       (Conj or)
                       (Vi worked))
                   (Conj or)
                   (Vi worked)))))
        (VP (Vi sighed)))
```

Q5.

a)

```
(ROOt    (S    (NP    (NP    (Det  every)
                              (Noun  sandwitch))
                      (PP    (prep   with)
                              (NP    (NP    (Det a)
                                            (Noun pickle))
                      (PP    (prep  on)
                              (NP    (Det the)
                                      (Noun floor)))))
            (VP    (Verb wanted)
                    (NP    (Det  a)
                            (Noun  president))))
        .))|
```

b)
　Yes, of course we have to care about using which one of derivations.

　Because two derivation have obviously different meaning with each other. As for the given version, both Preposition Phrase "with a pickle" and "on the floor" embellish the subject phrase----"every sandwich". However, under the other interpretation, only "with a pickle" is for sandwich. The second Preposition Phrase is a part of the Noun Phrase "a pickle on the floor". As a result, it is the pickle that on the floor instead of every sandwich.

　This way, first derivation means those sandwiches having a pickle on it are on the floor. While the other derivation means every sandwich whose pickle is on the floor wanted a president.

　Thus, the contrary meanings of two derivation make us to care about choosing the appropriate meaning we want.

Q6(a).No, the parser does not always recover the original derivation. Instead, it sometimes finds an alternative derivation. This is because the same sentence can be generated by different grammars, and parser will only find one of them, which is why alternative derivation appear.

Q6(b)

There is only one way to derive the string. Since there is a 'with',
NP -> NP PP is necessary here. And since 'every' is one part of the
determiner, NP -> Det Noun must be used for the first NP above. And
because of 'a' in the next place, NP -> Det Noun must be be used
here. ⋯⋯ After all these analysis, I find out there is only one way to
generate that noun phrase. It is mainly because of the restriction of
determiner and preposition. There is only 1 rule to generate determiner
and 1 rule to generate preposition. Therefore , there is only one way.

Q6(c)

.Yes, I find out that sentences with many noun phrase have more parse
than other sentence. It is because that noun phrase can be generated by
many different rules, which makes it have more parse than others.

Q6(d).i.(1)

All used grammar rules are below:

```
1   ROOT   S .      1/3
1   S   NP VP       1/1
1   NP  Det Noun       1/2
1   Det the       1/3
1   Noun    president      1/5
1   VP  Verb NP     1/1
1   Verb    ate     1/5
1   NP  Det Noun   1/2
1   Det the     1/3
1   Noun    sandwich       1/5
```

The last part of each line is the probability to use this line of grammar. The p(sentence) is the product of all the grammars above, which is 5.144032922e-05.

Q6(d).i.(2)It is because that there is only one way to generate this sentence. The best parse is the only parse. They both use grammar rules below.

1　ROOT　S .　　1/3

1　S　NP VP　　1/1

1　NP　Det Noun　　1/2

1　Det the　　1/3

1　Noun　president　　1/5

1　VP　Verb NP　　1/1

1　Verb　ate　1/5

1　NP　Det Noun　1/2

1　Det the　　1/3

1　Noun　sandwich　　1/5

Since they share the same grammar rules, the probability must be the same.

Q6(d).i.(3)It is because that there is only one way to generate this sentence. The best parse is the only parse. Therefore the probability that use this best parse to generate this sentence is 1.

Q6(d).ii.

The 0.5 means that there are two ways to generate this sentence. The best parse is one of the two ways.

Q6(d).iii.

Q6(d).iv.

The perplexity is equal to the E power of 2, in which E is the cross entropy. Therefore the perplexity is $2^{2.435185067} = 5.40833706189742$

Q6(d).v.

It is because that compress the corpus into the smallest size is only ideal. It is based the compress every information into exact several bits. However, the fact is that it is nearly impossible to compress terminal word into exact several bits. Therefore the ideal compress does not exist.

Q6(e)

For grammar2, after I use the command below:

./randsent grammar2.gr 10 |./parse -P -g grammar2.gr | ./prettyprint

It turns out that entropy is 1.796371671 bits

(# cross-entropy = 1.796371671 bits = -(-194.0081405 log-prob. / 108 words))

For grammar3, after I use the command below:

./randsent grammar3.gr 10 |./parse -P -g grammar3.gr | ./prettyprint

It turns out that entropy is 2.462806611 bits

(# cross-entropy = 2.462806611 bits = -(-918.626866 log-prob. / 373 words))

So the entropy of grammar3 is bigger than the entropy of grammar2

It is because that grammar 3 can present more sentences than grammar2, so its entropy in bigger.

For grammar, after I use the command below:

./randsent grammar.gr 10 |./parse -P -g grammar.gr | ./prettyprint

It turns out that entropy is 1.986691222 bits

(# cross-entropy = 1.986691222 bits = -(-480.7792757 log-prob. / 242 words))

It proves that grammar 3 can present more sentences than grammar 1, and grammar 1 can present more sentences than grammar2.

Q6(f)

If I use grammar3 to predict grammar2, after I use the command below:

./randsent grammar2.gr 10 |./parse -P -g grammar3.gr | ./prettyprint

It turns out that entropy is 2.607252847 bits

 (# cross-entropy = 2.607252847 bits = -(-237.2600091 log-prob. / 91 words))

Since the entropy of grammar2 is 1.796371671 , which is smaller than cross entropy. It proves that entropy is lower than cross entropy, which means that the same grammar predict better than di

Q7.

1.modification

Discussion:

Based on grammar3.gr, grammar7.gr mainly handle phenomena 7(a) and 7(d), that is the 'a'/'an' problem and the "embeded questions" in "I wonder".

As for 7(a), we found that, as a determiner, the/a/an will always appear in the start of a noun phrase without considering the situation holding preposition pharse behind. So we came up with an idea that generating a noun phrase which is able to determine using "a" or "an" by backward trees. Firstly, we have to separate nouns, adjectives, adverbs into starting with vowel or not respectively. Thus, we add the following preterminals: Det-an which stands for "an",Noun-vowel,Adj-vowel,Adv-vowel to indicate those words start with vowels. Besides, we also defined following preterminals like: ADJP, ADVP to help building the tree.Because, we might have several adjectives and several adverbs in front of a noun, but there is only one determiner. Again, only the word in the most front of a noun phrase, no matter it's an adverb or an adjective or a noun, can decide the determiner. So, the idea could be showed by the following tree:

```
NP---- Det + Noun
  ---- Det-an + Noun-vowel
  ---- ADJP + Noun
             ADJP---- Det + Adj
                  ---- Det-an + Adj-vowel
                  ---- ADJP + Adj
                  ---- ADVP + Adv
                             ADVP---- Det + Adv
                                  ---- Det-an + Adv-vowel
                                  ---- ADVP + Adv
```

It's easy to find that in this way we start from the end of an NP----a noun, then generate the whole phrase backwards by adding adjectives and adverbs and finally, the determiner. As long as it goes into a branch contains Det or Det-an, it won't have more branch any more, which means when determiner appears, the generation of NP complete. And this is why ADJP and ADVP exist. They prevent the process from generate more than one determiner. Eventually, using "a" or "an" just depends on having "-vowel" or not.

Then comes to 7(d), the words in front of "wh"s are quite fixed, we can just use "NP wonder"to create phrase similar with "I wonder", then, is just things about a question sentence, therefore we create a nonterminal named WHS. We grouped "wh" words into 3 groups----SWH, OWH, WDVVP. Firstly is subject question words: SWH, this is not that complex. Since it acts as subject, add a VP behind is fine. So we have a rule: WHS = SWH + VP. Then is the OWH stands for object "wh". Because the sentence after OWH has no object, so we have to generate this kind of sentence and that's why we define SWO(sentence without object). Thing is a SWO can embed in another SWO many times like :"what the president thought Sally thought a sandwitch ate", so we add two rules----SWO = NP + Vt and SWO = NP + Vt + SWO. Besides, sometimes a sentence may use intransitive verb and a preposition phrase as verb phrase, which leads to the object put behind a preposition word. Thus, we need another rule ---- WHS = OWH + NP + Vi + Prep. At last it's

the adverbial "wh", these "wh"s contain decorating information, so it's not the main part of a sentence, so Advwh + S is ok.

2.
is it true that every chief of staff pickled that I on an apple ate and kissed that every sandwich kissed an apparently ambivalent floor in every very fine apple ?

is it true that an ambivalent ambivalent pickle perplexed and kissed that an apple with I worked on the floor ?

it pickled the president that a president thought that the sandwich thought that the president ate that a sandwich on an apple sighed or sighed .

an apple under the very delicious apple perplexed that an apparently very very very very apparently pickled apple thought that a pickle thought and pickled and thought an ambivalent sandwich !

it worked or worked or worked or worked and worked and worked or worked and sighed or worked or worked and worked under an apple that every president sighed and worked or sighed and worked or worked or worked and worked or sighed or sighed .

I pickled that an apple sighed under a president !

it sighed that an apple in I with a pickled perplexed apple in Sally or every very apparently delicious floor and I wanted that an apparently very pickled apple pickled that a delicious floor and every floor sighed .

Sally wonder what worked .

an apparently very delicious ambivalent president and I wonder why an apparently very very apparently ambivalent apple worked in the very very pickled apple .

an ambivalent pickled chief of staff under an ambivalent ambivalent perplexed ambivalent delicious chief of staff wonder whom Sally wanted or pickled an apparently ambivalent apple under .