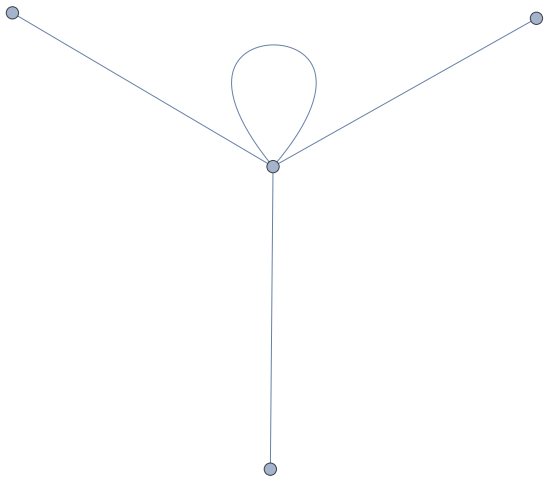
The pattern in modern English.

Morphological Relation System

What is this, over the time, human language evolve by "morph". I am not professional in linguistic, but any one using English will know the something similar between group of words, like “dependent,independent,...”

In[19]:=
```
Thread[# → WordData[#, "MorphologicalDerivatives", "List"]] & @ "love" // GraphPlot
```

Out[19]=



In[2]:=
```
dicWords = DictionaryLookup[];
```

In[•]:=
```
wordDerivativeToSystem =
 ParallelMap[Thread[# → WordData[#, "MorphologicalDerivatives", "List"]] &,
      dicWords] // DeleteCases[#, _Missing] & //
   Select[#, ListQ@Values@# && Length@# ≠ 0 &] & // Flatten //
  Select[#, StringQ @ Keys @# && StringQ@Values@# &] &
```

Out[•]=
```
{abandon → abandonment, abandoning → abandonment, abandonment → abandon, abandons → abandonment,
 abase → abasement, abased → abasement, abasement → abase, abases → abasement, abash → abashment,
 abashes → abashment, abashing → abashment, abashment → abash, abasing → abasement, abate → abatable,
 abate → abatement, abate → abator, ··· 60525 ···, zoologist → zoology, zoologists → zoology,
 zoology → zoological, zoology → zoologist, zoom → zoom, zoomed → zoom, zooming → zoom,
 zooms → zoom, Zoroaster → Zoroastrian, Zoroastrian → Zoroaster, Zoroastrian → Zoroastrian,
 Zoroastrians → Zoroastrian, zygote → zygotic, zygotes → zygotic, zygotic → zygote}
```

Full expression not available (original memory size: 8.3 MB)

In[]:=
```
wordDerivativeFromSystem =
 ParallelMap[Thread[# → WordData[#, "MorphologicalSource", "List"]] &, dicWords] //
     DeleteCases[#, _Missing] & //
    Select[#, ListQ@Values@# && Length@# ≠ 0 &] & // Flatten //
  Select[#, StringQ @ Keys @# && StringQ@Values@# &] &
```

Out[]=
```
{abandon → abandonment, abandoning → abandonment, abandonment → abandon, abandons → abandonment,
 abase → abasement, abased → abasement, abasement → abase, abases → abasement, abash → abashment,
 abashes → abashment, abashing → abashment, abashment → abash, abasing → abasement, abate → abatable,
 abate → abatement, abate → abator, ··· 60553 ···, zoologist → zoology, zoologists → zoology,
 zoology → zoological, zoology → zoologist, zoom → zoom, zoomed → zoom, zooming → zoom,
 zooms → zoom, Zoroaster → Zoroastrian, Zoroastrian → Zoroaster, Zoroastrian → Zoroastrian,
 Zoroastrians → Zoroastrian, zygote → zygotic, zygotes → zygotic, zygotic → zygote}
```

Full expression not available (original memory size: 8.3 MB)

In[]:=
```
graphMorp = (UndirectedEdge[Keys@#, Values@#] &/@
     ({(wordDerivativeToSystem), wordDerivativeFromSystem} // Flatten) // Union) //
  Graph[#, VertexLabels → Automatic] &
```

Out[]=
```
Graph[  Vertex count: 44426
                                                          Edge count: 60635 ]
```

In[]:=
```
componentWordMorp =
 graphMorp // WeaklyConnectedComponents // Select[#, Length@# > 1 &] &
```

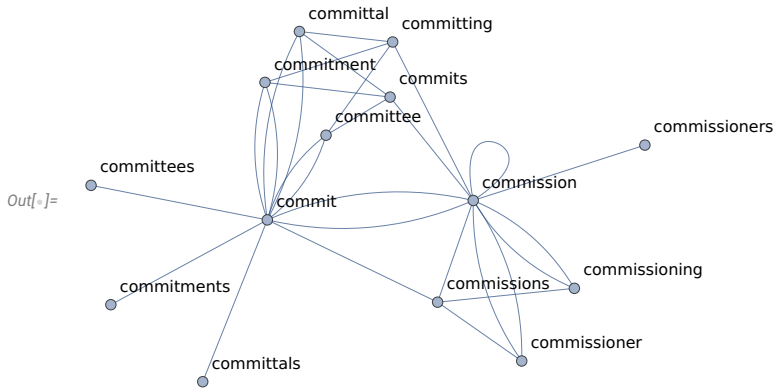
Out[]=
```
{{extensiveness, extensive, large, largest, extend, extending, extends, largeness, larges,
  extendible, extensible, extension, extensor, extent, extensions, extensors, extents,
  comprehensive, extensional, comprehend, comprehending, comprehends, comprehensiveness,
  comprehendible, comprehensible, comprehension, comprehensions, comprehensibility},
 {valuated, valuation, valuator, value, valuate, valuates, valuating, evaluate, evaluated,
  evaluates, evaluating, valuable, valuer, valuers, valuing, valuations, evaluation, evaluative,
  evaluator, evaluations, evaluators, valuableness, valuables}, ··· 9938 ···, {venom, venomous}}
```

Full expression not available (original memory size: 2.5 MB)

In[]:=
```
componentGraphWordMorp = graphMorp // WeaklyConnectedGraphComponents;
```

In[•]:=
```
componentGraphWordMorp[50]
```

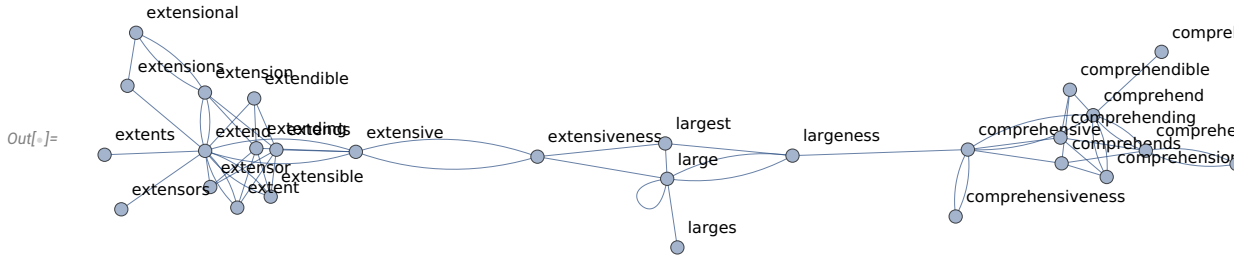
Out[•]=



Surprise, around 100000 dictionary English word, if group them based on they Morphology, we have only 10000 groups. Some group easy to understand, but some groups, like

In[•]:=
```
componentGraphWordMorp[1]
```

Out[•]=



A bit hard to understand, why “large” derivative related from extensive group and “comprehensive”

In[•]:=
```
WordData["extensiveness", "MorphologicalDerivatives", "List"]
```

Out[•]=
```
{extensive, large}
```

In[•]:=
```
WordData["largest", "MorphologicalSource", "List"]
```

Out[•]=
```
{extensiveness, large, largeness}
```

In[•]:=
```
DictionaryLookup[RegularExpression[".*larg.*"]]
```

Out[•]=
```
{enlarge, enlargeable, enlarged, enlargement, enlargements, enlarger,
 enlargers, enlarges, enlarging, large, largehearted, largely, largeness,
 larger, larges, largess, largest, largish, largo, largos, overlarge}
```

```
In[•]:= Select[componentWordMorp, Length@((StringPosition[#, "larg"] // Flatten)) > 0 &]
```

```
Out[•]= {{extensiveness, extensive, large, largest, extend, extending, extends,
    largeness, larges, extendible, extensible, extension, extensor, extent,
    extensions, extensors, extents, comprehensive, extensional, comprehend,
    comprehending, comprehends, comprehensiveness, comprehendible,
    comprehensible, comprehension, comprehensions, comprehensibility},
   {enlarging, enlargement, enlarger, enlarge, enlarges, enlargements, enlargers},
   {largo, largos}}
```

Surprisingly, “largo” and “large” in different group. Despite of similar in written form

```
In[•]:= # → Column [ Text /@ WordData[#, "Definitions", "List"], Frame → All] & /@
 {"largo", "large"}
```

```
Out[•]= {largo →
```

(music) a composition or passage that is to be performed in a slow and dignified manner
very slow in tempo and broad in manner
slowly and broadly

,

large →

a garment size for a large person
in an advanced stage of pregnancy
having broad power and range and scope
conspicuous in position or importance
generous and understanding and tolerant
above average in size or number or quantity or magnitude or extent
ostentatiously lofty in style
fairly large or important in effect; influential
in a boastful manner
with the wind abaft the beam
at a distance, wide of something (as of a mark)

}

```
In[•]:= Select[componentWordMorp, Length@((StringPosition[#, "depen"] // Flatten)) > 0 &]
```

```
Out[•]= {{dependant, depend, depended, depending, depends,
    dependency, dependent, dependencies, dependence, dependents},
   {interdepend, interdependence, interdependency, interdependent},
   {undependableness, undependable, undependability},
   {dependability, dependable, dependableness},
   {independence, independent, independency}}
```

```
In[•]:= WordData[#, "MorphologicalDerivatives", "List"] & /@
 {"independence", "independent", "independency"}
```

```
Out[•]= {{independent}, {independence, independency}, {independent}}
```

How about split groups of words based on Synonyms

In[20]:=
```
wordSynonymsSystem =
 ParallelMap[Thread[# → WordData[#, "Synonyms", "List"]] &, dicWords] //
    DeleteCases[#, _Missing] & //
   Select[#, ListQ@Values@# && Length@# ≠ 0 &] & // Flatten //
  Select[#, StringQ @ Keys @# && StringQ@Values@# &] &
```

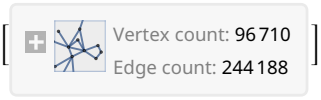
Out[20]=

{a → A, Aachen → Aix-la-Chapelle, Aachen → Aken, aah → ooh, aardvark → ant bear, aardvark → anteater,
 aardvark → Orycteropus afer, aardvarks → aardvark, aardvarks → ant bear, aardvarks → anteater,
 aardvarks → Orycteropus afer, Aaron → Hank Aaron, Aaron → Henry Louis Aaron, abacuses → abacus,
 ··· 288 904 ···, zucchini → courgette, zucchinis → courgette, zucchinis → zucchini,
 Zulus → Zulu, zwieback → Brussels biscuit, zwieback → rusk, zwieback → twice-baked bread,
 Zwingli → Huldreich Zwingli, Zwingli → Ulrich Zwingli, Zworykin → Vladimir Kosma Zworykin,
 zygote → fertilized ovum, zygotes → fertilized ovum, zygotes → zygote, zymurgy → zymology}

Size in memory: 39.4 MB | + Show more | Show all | Iconize | Store full expression in notebook

In[73]:=
```
wordSynonymsSystemGraph =
 (Sort /@ (UndirectedEdge[#[[1]], #[[2]] &/@ wordSynonymsSystem )) //
   DeleteDuplicates // Graph
```

Out[73]=



In[66]:=
```
synonymsCluster = wordSynonymsSystemGraph // ConnectedComponents;
```

In[35]:=
```
synonymsCluster // Length
```

Out[35]=

16 147

Oh, we have 16000 clusters here

In[74]:=
```
synonymsClusterGraph = wordSynonymsSystemGraph // ConnectedGraphComponents;
```

In[43]:=
```
VertexCount /@ synonymsClusterGraph
```
Out[43]=
```
{43 071, 45, 43, 40, 34, 34, 32, 30, 29, 29, 28, 28, 27, 25, 25, 25, 25, 24, 24, 24, 24, 23, 23, 23,
 23, 22, 22, 22, 22, 22, 21, 21, 21, 21, 21, 21, 20, 20, 20, 20, 19, 19, 19, 19, 19, 19, 19, 19,
 19, 19, 18, 18, 18, 18, 18, 18, 18, 18, 17, 17, 17, 17, 17, 17, 17, 17, 17, 16, 16, 16, 16, 16,
 16, 16, 16, 16, 16, 16, 16, 16, 16, 16, 16, 15, 15, 15, 15, 15, 15, 15, 15, 15, 15, 15, 15, 15,
 15, 15, 15, 15, 15, 15, 15, 15, 15, 15, 15, 15, 14, 14, 14, 14, 14, 14, 14, 14, 14, 14, 14, 14,
 14, 14, 14, 14, 14, 14, 14, 14, 14, 14, 14, 14, 14, 14, 14, … 15 877 …, 2, 2, 2, 2, 2, 2, 2,
 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2,
 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2,
 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2,
 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2}
```
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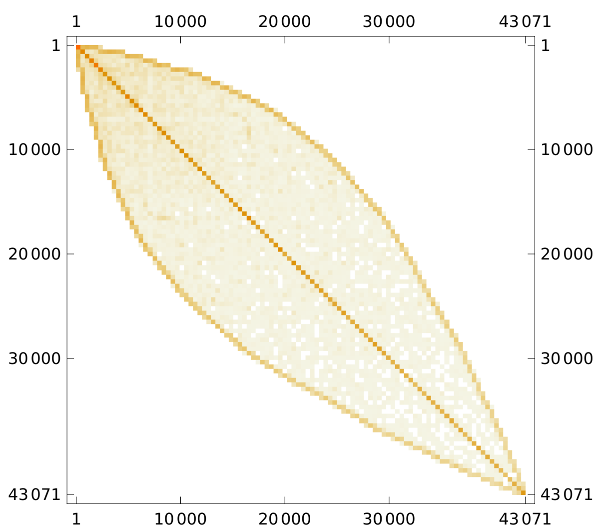
Wow, the biggest cluster, why it is so huge

In[75]:=
```
adjMatrix = synonymsClusterGraph[[1]] // AdjacencyMatrix
```
Out[75]=
```
SparseArray[ Specified elements: 370 990  Dimensions: {43 071, 43 071} ]
```
Data not in notebook. Store now

In[76]:=
```
MatrixPlot[adjMatrix]
```
Out[76]=



In[92]:=
```
synonymsClusterGraph[[1]] // VertexDegree // Counts // KeySort
```

Out[92]=
```
<|1 → 2208, 2 → 6270, 3 → 4677, 4 → 4639, 5 → 3560, 6 → 3229, 7 → 2565, 8 → 2198,
 9 → 1789, 10 → 1441, 11 → 1242, 12 → 1221, 13 → 858, 14 → 766, 15 → 634,
 16 → 585, 17 → 507, 18 → 446, 19 → 378, 20 → 369, 21 → 286, 22 → 245, 23 → 241,
 24 → 217, 25 → 184, 26 → 181, 27 → 134, 28 → 180, 29 → 123, 30 → 123, 31 → 118,
 32 → 112, 33 → 83, 34 → 84, 35 → 71, 36 → 62, 37 → 71, 38 → 51, 39 → 47,
 40 → 59, 41 → 59, 42 → 64, 43 → 38, 44 → 26, 45 → 41, 46 → 54, 47 → 37, 48 → 32,
 49 → 35, 50 → 27, 51 → 30, 52 → 16, 53 → 25, 54 → 19, 55 → 15, 56 → 25, 57 → 20,
 58 → 12, 59 → 20, 60 → 8, 61 → 10, 62 → 15, 63 → 15, 64 → 8, 65 → 12, 66 → 11,
 67 → 4, 68 → 8, 69 → 8, 70 → 8, 71 → 2, 72 → 10, 73 → 1, 74 → 6, 75 → 7, 77 → 7,
 78 → 3, 80 → 1, 81 → 4, 82 → 3, 83 → 3, 84 → 4, 85 → 4, 87 → 6, 88 → 1, 89 → 1,
 91 → 1, 92 → 4, 94 → 1, 95 → 1, 96 → 2, 97 → 1, 98 → 2, 99 → 3, 100 → 4, 101 → 1,
 102 → 3, 103 → 3, 104 → 1, 106 → 1, 107 → 1, 109 → 1, 111 → 1, 114 → 1, 115 → 2,
 119 → 1, 120 → 1, 123 → 1, 127 → 1, 129 → 1, 134 → 1, 137 → 2, 143 → 1, 144 → 1,
 146 → 1, 155 → 1, 156 → 1, 169 → 1, 175 → 1, 182 → 1, 190 → 1, 201 → 1|>
```

Wait, just a quick skim through this small vertex degree list, there is a word that have ... 201 synonyms, or I mean the vertex of this word have 201 edges connect with it! What the hell is that word. There are many word have hundreds synonyms too!.

In[94]:=
```
synonymsClusterGraph[[1]] // VertexDegree // Position[#, 201] &
```

Out[94]=
```
{{663}}
```

In[97]:=
```
(synonymsClusterGraph[[1]] // VertexList)[[663]]
```

Out[97]=
```
break
```

In[102]:=
```
VertexDegree[synonymsClusterGraph[[1]], "break"]
```

Out[102]=
```
201
```

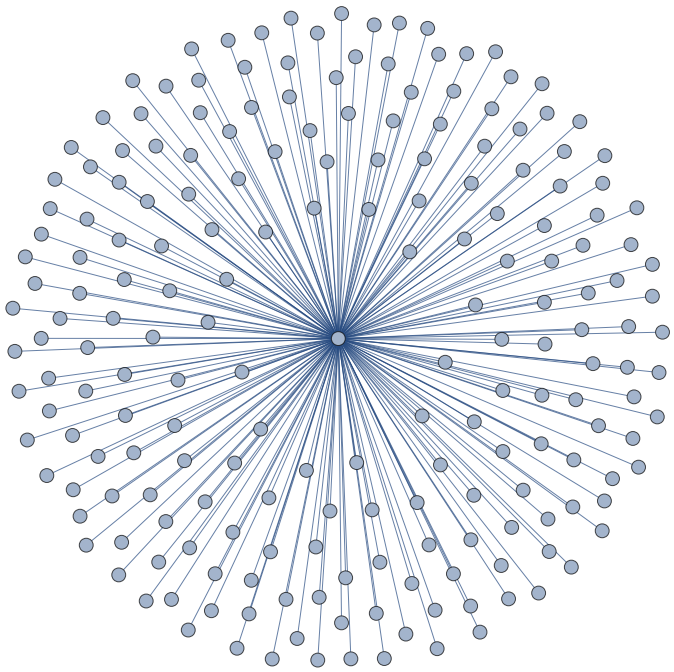
In[101]:=
```
WordData["break", "Synonyms", "List"]
```

Out[101]=
```
{bankrupt, better, breach, breakage, break away, break-dance, break dance,
 break down, break in, breaking, break off, break of serve, break out,
 breakout, break up, bring out, bump, burst, bust, cave in, check, collapse,
 come apart, conk out, crack, damp, dampen, demote, develop, die, disclose,
 discontinue, discover, disruption, divulge, erupt, expose, fail, fall apart,
 fall in, falling out, fault, faulting, founder, fracture, gaolbreak, gap,
 geological fault, get around, get out, give, give away, give out, give way,
 go, go against, go bad, good luck, happy chance, infract, intermission,
 intermit, interrupt, interruption, jailbreak, kick downstairs, let on,
 let out, offend, open frame, part, pause, prisonbreak, prison-breaking,
 recess, recrudesce, relegate, respite, reveal, rift, ruin, rupture,
 separate, severance, shift, smash, snap off, soften, split, split up, stop,
 suspension, time out, transgress, unwrap, violate, weaken, wear, wear out}
```

In[107]:=
```
synonymsOfBreak =
  Select[synonymsClusterGraph[[1]] // EdgeList, #[[1]] == "break" || #[[2]] == "break" &];
```

In[108]:=
```
synonymsOfBreak // Graph
```

Out[108]=



In[109]:=
```
synonymsOfBreak // Shallow
```
Out[109]//Shallow=
```
{break ⟷ bump, break ⟷ check, break ⟷ go,
 break ⟷ stop, break ⟷ bumped, break ⟷ bumping, break ⟷ bumps,
 break ⟷ checking, break ⟷ checks, break ⟷ breaks, ≪191≫}
```

Huh? what is relation of break and bump

In[111]:=
```
WordData["bump", "Synonyms"]
```
Out[111]=
```
{{bump, Noun, Impact} → {blow},
 {bump, Noun, Projection} → {bulge, excrescence, extrusion, gibbosity,
   gibbousness, hump, jut, prominence, protrusion, protuberance, swelling},
 {bump, Noun, Hurt} → {}, {bump, Verb, RunInto} → {knock},
 {bump, Verb, Displace} → {dislodge}, {bump, Verb, TripTheLightFantasticToe} → {},
 {bump, Verb, Happen} → {chance, encounter, find, happen},
 {bump, Verb, Designate} → {break, demote, kick downstairs, relegate}}
```

Oh! the problem that in “designate” sense form of bump, there is a link to “break”, “break” someone is meaning demote someone. Our algorithm work, but maybe it just so general, or the data so rich that why everything keep link instead of separate themself.

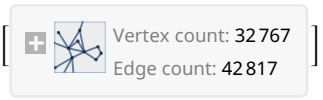
Let try to minimize our examine set to Noun only

In[115]:=
```
nounWords = WordList["Noun"];
```

In[116]:=
```
nounSynonymsSystem =
 ParallelMap[Thread[# → WordData[{#, "Noun"}, "Synonyms", "List"]] &, nounWords] //
     DeleteCases[#, _Missing] & //
    Select[#, ListQ@Values@# && Length@# ≠ 0 &] & // Flatten //
  Select[#, StringQ @ Keys @# && StringQ@Values@# &] &
```
Out[116]=
```
{a → A, aardvark → ant bear, aardvark → anteater, aardvark → Orycteropus afer, abalone → ear-shell,
 abandon → unconstraint, abandon → wantonness, abandon → wildness, abandonment → defection,
 abandonment → desertion, abandonment → forsaking, abasement → abjection, abasement → degradation,
 abasement → humiliation, ··· 62378 ···, zone → zona, zoo → menagerie, zoo → zoological garden,
 zoologist → animal scientist, zoology → fauna, zoology → zoological science, zoom → rapid climb,
 zoom → rapid growth, zoom → soar, zucchini → courgette, zwieback → Brussels biscuit,
 zwieback → rusk, zwieback → twice-baked bread, zygote → fertilized ovum}
```
Size in memory: 8.5 MB | + Show more | Show all | Iconize | Store full expression in notebook

In[132]:=
```
nounSynonymsSystemGraph =
 (Sort /@ (#[[1]] ⟷ #[[2]] & /@ nounSynonymsSystem)) // DeleteDuplicates //
  Graph[#, VertexLabels → Automatic] &
```

Out[132]=



In[120]:=
```
nounSynonymsSystemGraphComponent = nounSynonymsSystemGraph // ConnectedComponents;
```

In[135]:=
```
Length /@ nounSynonymsSystemGraphComponent // Shallow
```

Out[135]//Shallow=
```
{11 689, 37, 35, 32, 31, 29, 27, 27, 27, 27, ≪6465≫}
```

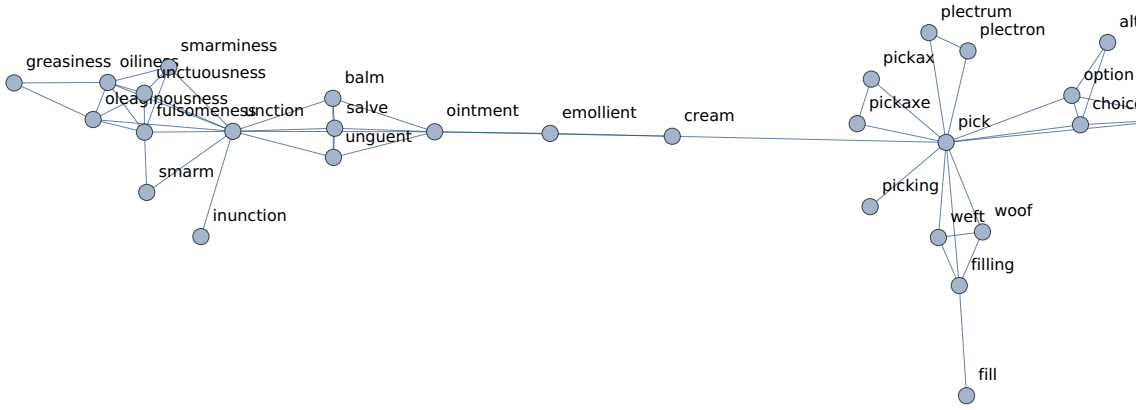
Oops, understand, English simply so rich at the senses of each words and even each senses have multi synonyms too.

In[133]:=
```
graphsSystem2 = nounSynonymsSystemGraph // ConnectedGraphComponents;
```

If we ignore the exceptional huge cluster, let check remain cluster

In[136]:=
```
graphsSystem2[[2]]
```

Out[136]=



Hum, I don' t know fill can act like a noun

In[150]:=
```
Column[#, Frame → All] &@ (Text /@ WordData[{"fill", "Noun"}, "Definitions"])
```

Out[150]=

{fill, Noun, Sufficiency} → a quantity sufficient to satisfy
{fill, Noun, Stuff} → any material that fills a space or container

Oh, the “magic” of English, how on Earth "fill" which act like a noun existed. but it really existed.

Normally I never expect a word that have so many synonyms, but in the end most of us just touch a very basic of English skill in our era. a simple and common like “break”. If count all of its “sense”, can have up to 200 synonyms, such a massive amount of knowledge if we dig into it

Scratchpad

In[153]:=
```
SetDirectory["~/nhannht-projects/nature"];
```

In[•]:=
```
NotebookSave[EvaluationNotebook[], FileNameJoin[{Directory[], "humanlanguage2.nb"}]]
```

In[152]:=
```
VerminExportKeepSyntaxHighLight[]
```

In[154]:=
```
Export[FileNameJoin[{Directory[], "humanlanguage2.pdf"}], EvaluationNotebook[]]
```