Epistemology of BTC

This notebook serves to analyze best approaches to explaining BTC.

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Raw data

This data comes from the file “btc-epistemology.xlsx”. Just copy the range that includes the subjects column and the prerequisite “1” marks.

In[ ]:=
```
exceldata = "block
    1        1    1                                  1

block reward    1        1
    1    1               1        1    1

blockchain    1            1
    1                        1

block time    1
    1    1

change
    1                                        1    1    1    1

change address
    1                                             1    1    1            1

coinbase tx    1    1
    1            1    1    1    1            1

halving        1        1
    1            1        1

hashing
    1

issuance        1    1    1            1
    1               1           1        1

mempool    1        1
```

```
    1                              1

mining    1    1    1                1
    1        1        1    1    1                1    1

mining difficulty    1            1
    1                    1    1

mining diff adj                1
    1            1    1        1

proof of work            1
    1            1    1

receive
    address
                 1            1

satoshi
         1

transaction    1                1
    1                    1                    1    1        1

tx fee
    1        1    1

transactions
    1
    1            1

utxo             1        1
    1    1    1
";

rawdata = ImportString[
  StringReplace[
   StringReplace[
    StringReplace[
     StringReplace[
      StringReplace[exceldata, {
        "\t\n" → ", 0\n"
        , "\t" → ", "
       }
      ]
      , {
       ", ," → ", 0,"
```

```
      }]
     , {
      ", ," → ", 0,"
     }]
    , {",  " → ", 0"}
   ]
   , "\n\n" → "\n"
  ]
  , "CSV"
 ]
```

Out[ ]=

```
{{block, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 1, 1, 0, 0, 0, 0, 0, 0, 0, 1, 0},
 {block reward, 1, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 0, 0, 0, 1, 0, 1, 1, 0},
 {blockchain, 1, 0, 0, 1, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0},
 {block time, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 0, 0, 0, 0, 0, 0, 0, 0},
 {change, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 1, 1, 0, 0},
 {change address, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 1, 0, 0, 1},
 {coinbase tx, 1, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 1, 1, 1, 1, 0, 0, 1},
 {halving, 0, 1, 0, 1, 0, 0, 1, 0, 0, 1, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0},
 {hashing, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0},
 {issuance, 0, 1, 1, 1, 0, 0, 1, 1, 0, 0, 0, 1, 0, 0, 1, 0, 1, 0, 0, 0, 0},
 {mempool, 1, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 1, 0, 0},
 {mining, 1, 1, 1, 0, 0, 0, 1, 0, 1, 0, 1, 0, 1, 1, 1, 0, 0, 0, 1, 1, 0},
 {mining difficulty, 1, 0, 0, 1, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 1, 0, 0, 0, 0, 0, 0},
 {mining diff adj, 0, 0, 0, 1, 0, 0, 0, 0, 1, 0, 0, 1, 1, 0, 1, 0, 0, 0, 0, 0, 0},
 {proof of work, 0, 0, 1, 0, 0, 0, 0, 0, 1, 0, 0, 1, 1, 0, 0, 0, 0, 0, 0, 0, 0},
 {receive address, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 1},
 {satoshi, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0},
 {transaction, 1, 0, 0, 0, 1, 1, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 1, 0, 1, 0, 0},
 {tx fee, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 1, 1, 0, 0, 0},
 {transactions, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 1},
 {utxo, 0, 0, 1, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 1, 0, 0, 0, 0, 0, 0}}
```

In[ ]:=

```
subjects = rawdata[[All, 1]];
data =  rawdata[[All, 2 ;;]];
```

In[ ]:=

```
literals =
  Sort[Flatten[List[subjects[[#[[1]]]] → subjects[[#[[2]]]] & /@ Position[data, 1]]];
literals // Length
```

Out[ ]=

```
100
```

In[ ]:=

```
Column[literals]
```

Out[ ]=

```
block → hashing
block → mempool
block → mining
block → transactions
blockchain → block
```

blockchain → block time
blockchain → hashing
blockchain → proof of work
block reward → block
block reward → blockchain
block reward → mining
block reward → mining difficulty
block reward → satoshi
block reward → transactions
block reward → tx fee
block time → block
block time → mining
block time → mining difficulty
change → change address
change → receive address
change → satoshi
change → transaction
change → tx fee
change address → change
change address → receive address
change address → satoshi
change address → transaction
change address → utxo
coinbase tx → block
coinbase tx → block reward
coinbase tx → mining
coinbase tx → proof of work
coinbase tx → receive address
coinbase tx → satoshi
coinbase tx → transaction
coinbase tx → utxo
halving → block reward
halving → block time
halving → coinbase tx
halving → issuance
halving → mining
hashing → proof of work
issuance → blockchain
issuance → block reward
issuance → block time
issuance → coinbase tx
issuance → halving
issuance → mining
issuance → proof of work
issuance → satoshi
mempool → block
mempool → blockchain
mempool → mining
mempool → tx fee
mining → block
mining → blockchain
mining → block reward
mining → coinbase tx
mining → hashing

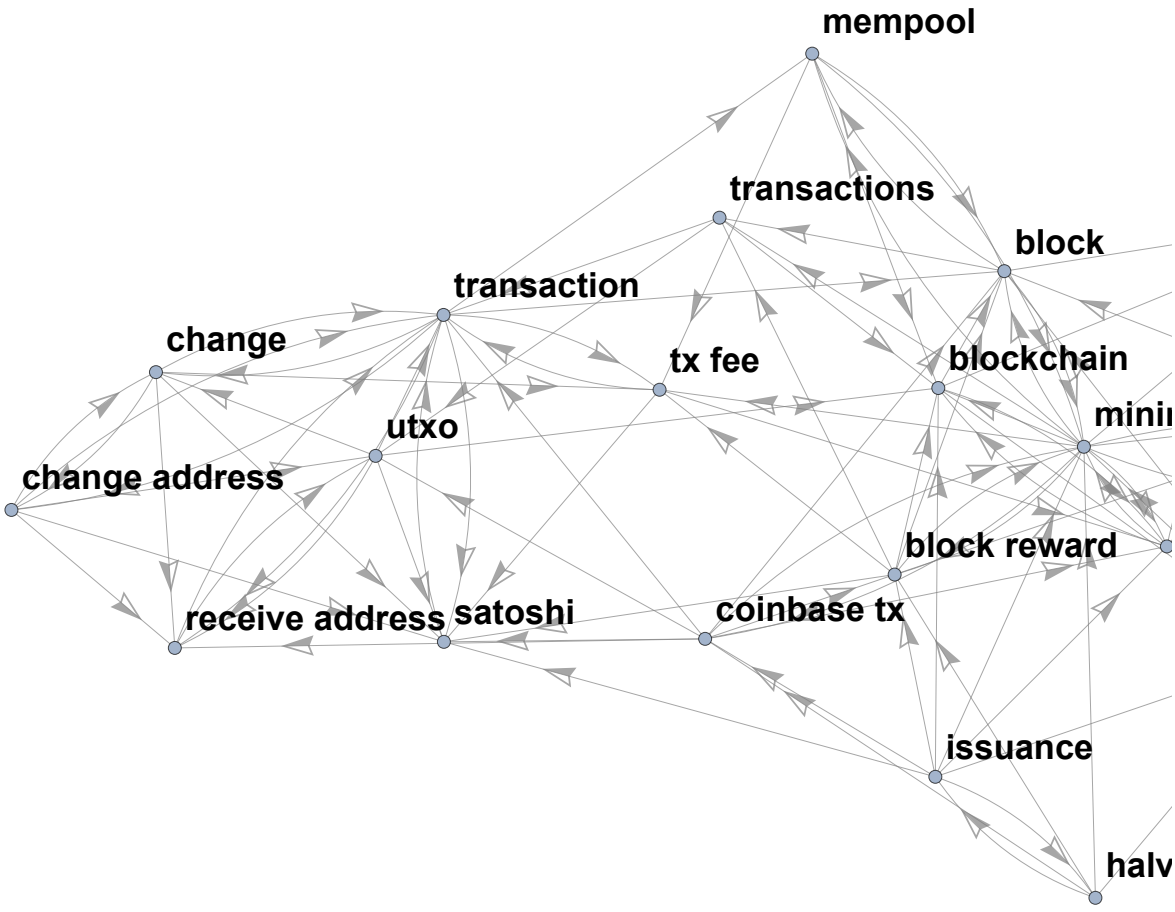
```
mining → mempool
mining → mining diff adj
mining → mining difficulty
mining → proof of work
mining → transactions
mining → tx fee
mining diff adj → block time
mining diff adj → hashing
mining diff adj → mining
mining diff adj → mining difficulty
mining diff adj → proof of work
mining difficulty → block
mining difficulty → block time
mining difficulty → hashing
mining difficulty → mining diff adj
mining difficulty → proof of work
proof of work → blockchain
proof of work → hashing
proof of work → mining
proof of work → mining difficulty
receive address → transaction
receive address → utxo
satoshi → transaction
transaction → block
transaction → change
transaction → change address
transaction → mempool
transaction → receive address
transaction → satoshi
transaction → tx fee
transactions → blockchain
transactions → transaction
transactions → utxo
tx fee → proof of work
tx fee → satoshi
tx fee → transaction
utxo → blockchain
utxo → change
utxo → receive address
utxo → satoshi
utxo → transaction
```

In[•]:=
```
vertices = VertexList[literals]
```

Out[•]=
```
{block, hashing, mempool, mining, transactions, blockchain,
 block time, proof of work, block reward, mining difficulty,
 satoshi, tx fee, change, change address, receive address,
 transaction, utxo, coinbase tx, halving, issuance, mining diff adj}
```

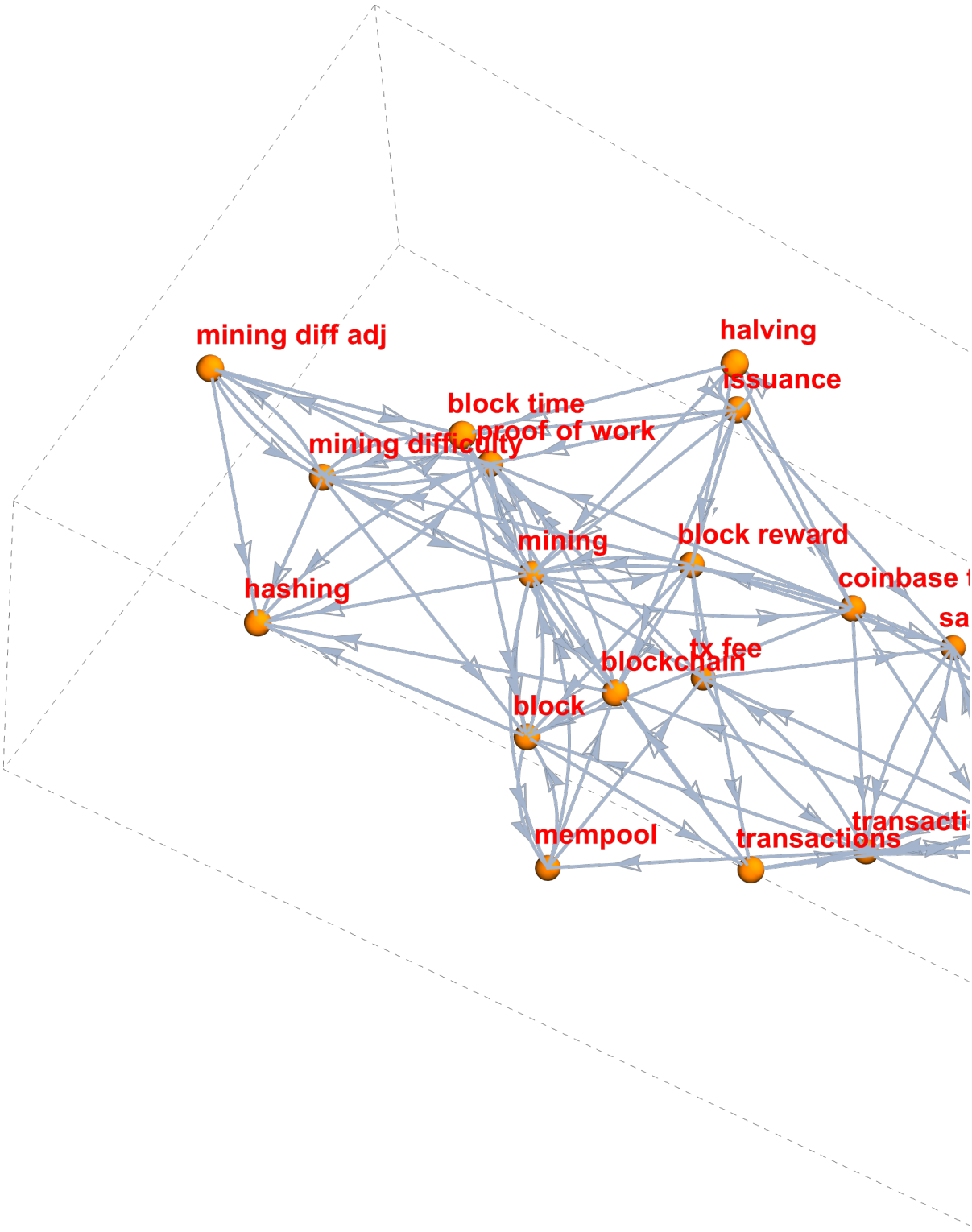
In[ ]:=
```
twoD = Graph[
  literals
  , VertexSize → Small
  , VertexLabels → "Name"
  , VertexLabelStyle → Directive[Black, 18, Bold]
  , EdgeStyle → Directive[Gray]
  , EdgeShapeFunction → {{"CarvedArrow", "ArrowSize" → .02}}
 ]
```

Out[ ]=



In[ ]:=
```
threeD = Graph3D[
  literals
  , Boxed → True
  , BoxStyle → Directive[Dashed]
  , VertexLabels → "Name"
  , VertexLabelStyle → Directive[Red, 18, Bold]
  , VertexSize → 0.2
  , VertexStyle → Orange
  , EdgeStyle → Directive[Thick]
  , EdgeShapeFunction → {{"CarvedArrow", "ArrowSize" → .02}}
 ]
```

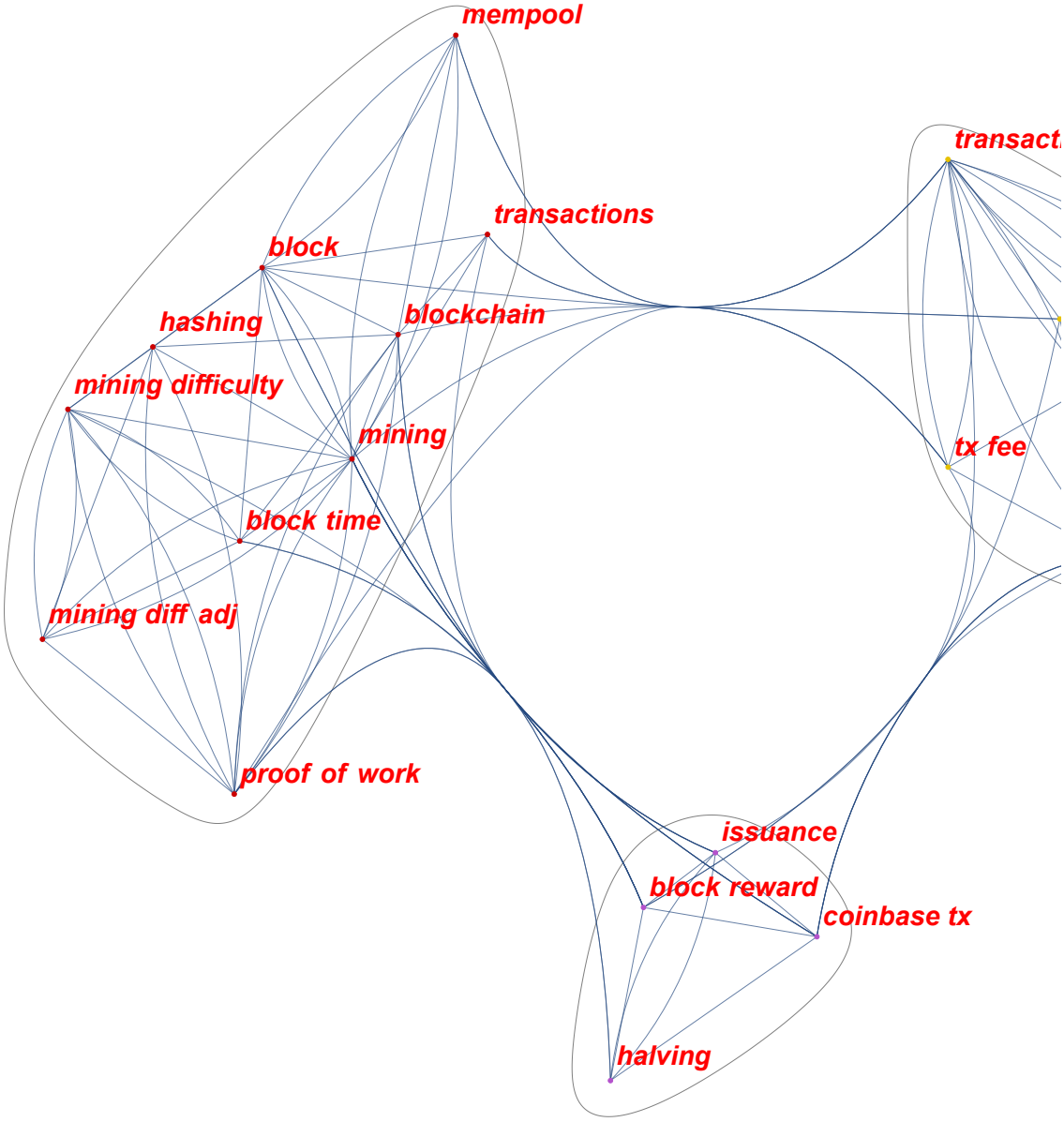
Out[ ]=


mining diff adj
halving
issuance
block time
proof of work
mining difficulty
mining
block reward
hashing
coinbase
sa
tx fee
blockchain
block
mempool
transactions
transacti

Community Graph

In[ ]:=
```
CommunityGraphPlot[
 literals
 , ImageSize → 900
 , ImageMargins → 20
 , VertexSize → 0.05
 ,  VertexLabels → "Name"
 , CommunityBoundaryStyle → Automatic
 , VertexLabelStyle → Directive[Red, Italic, Bold, 15]
 (*,EdgeShapeFunction→{{"CarvedArrow","ArrowSize"→.01}}*)
]
```

Out[ ]=

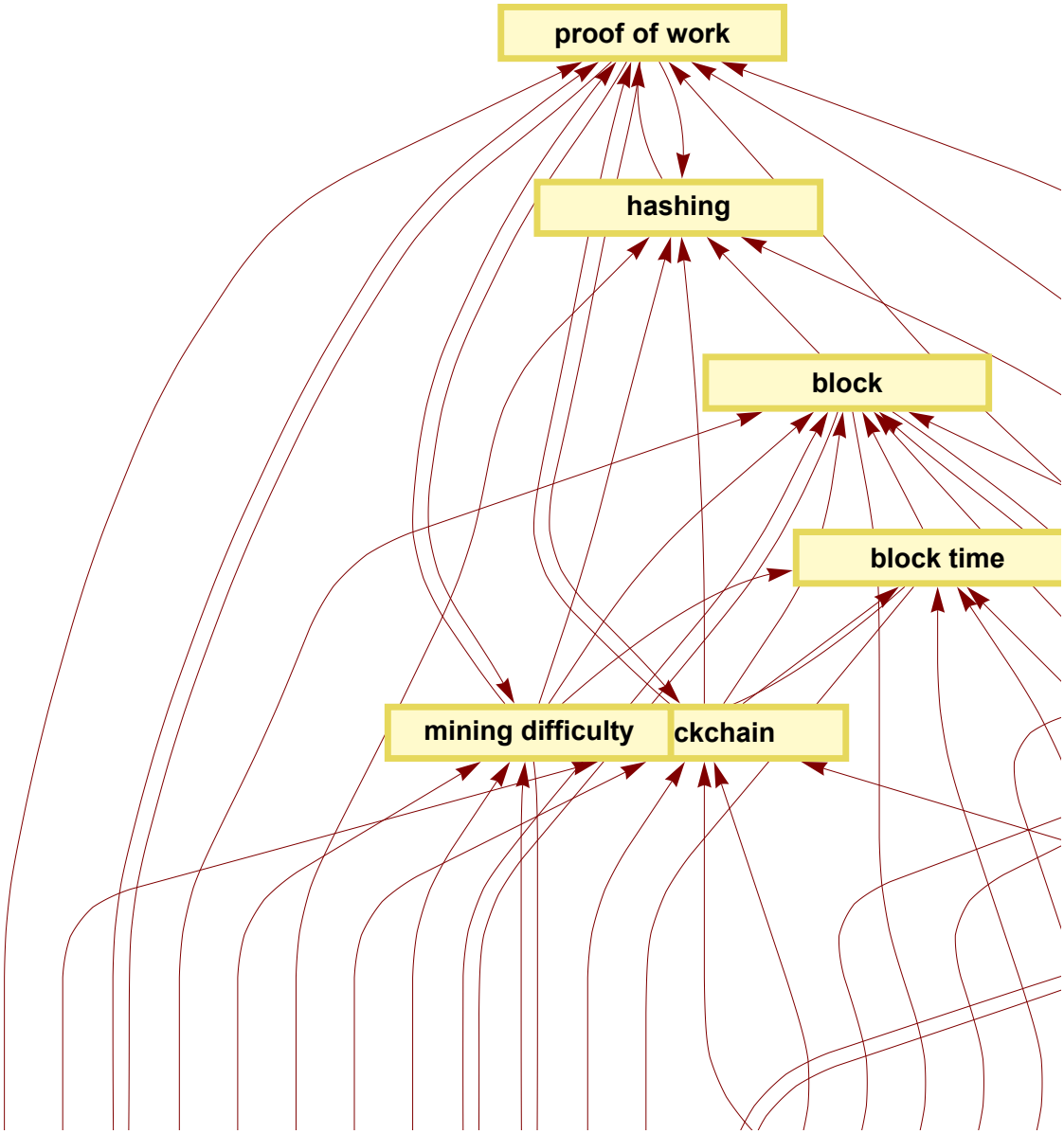


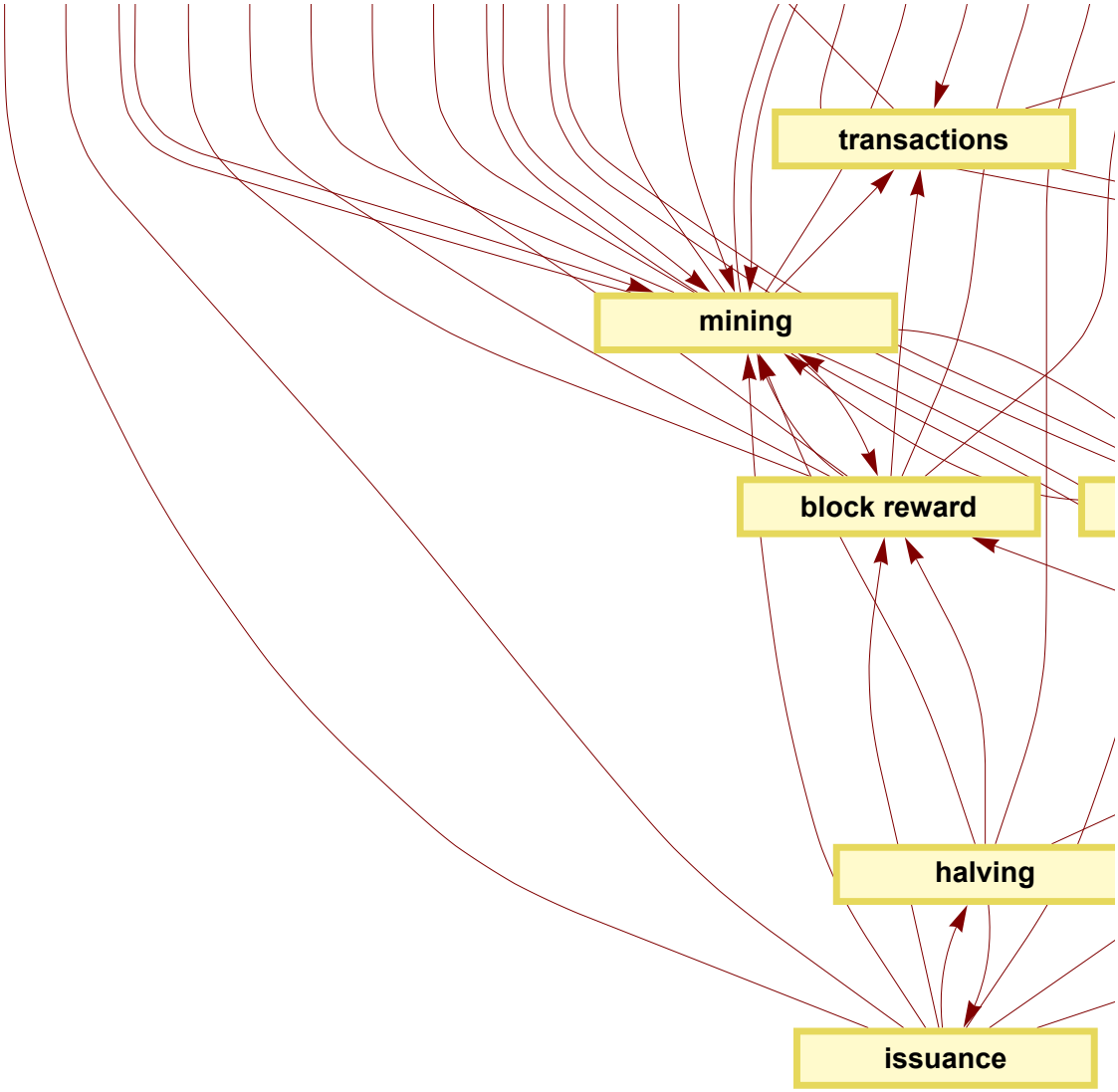
Layered Graph

In[ ]:=

In[ ]:=
```
LayeredGraphPlot[
 literals
 , Bottom
 , ImageSize → 1200
 , ImageMargins → 20
 , VertexSize → {2.75, .5}
 , AspectRatio → 1
 , VertexLabelStyle → Directive[Bold, 15]
 (*,VertexSize→0.05
 , VertexLabels→"Name"
 ,EdgeShapeFunction→{{"CarvedArrow","ArrowSize"→.02}}
 *)
 , PlotTheme → "ClassicDiagram"
]
```

Out[ ]=





In[ ]:=
```
ReverseSortBy[
 Table[{vertices[[x]], VertexDegree[literals][[x]]}, {x, 1, Length[vertices]}], Last]
```

Out[ ]=
```
{{mining, 20}, {transaction, 15}, {proof of work, 12}, {block, 12},
 {coinbase tx, 11}, {block reward, 11}, {blockchain, 11}, {mining difficulty, 10},
 {utxo, 9}, {satoshi, 9}, {issuance, 9}, {tx fee, 8}, {change, 8},
 {block time, 8}, {receive address, 7}, {mining diff adj, 7}, {mempool, 7},
 {hashing, 7}, {change address, 7}, {transactions, 6}, {halving, 6}}
```

Scoring prerequisites and complexities

Prerequisites Scores

In[ ]:=
```
prerequisites = AssociationThread @@ (ReverseSortBy[
        Table[{
          vertices⟦x⟧
          , VertexInDegree[literals]⟦x⟧}
         , {x, 1, Length[vertices]
         }]
        , Last]
       // Transpose
   );
prerequisites // Dataset[
   #
   , ItemStyle → {Black}
   , HeaderStyle → Bold
   , HeaderBackground → LightYellow
   , MaxItems → (vertices // Length)
  ] &
```

Out[ ]=

mining	9
transaction	8
satoshi	8
proof of work	8
block	8
blockchain	7
hashing	6
tx fee	5
receive address	5
mining difficulty	5
block time	5
utxo	4
block reward	4
transactions	3
mempool	3
coinbase tx	3
change	3
mining diff adj	2
change address	2
issuance	1
halving	1

Complexity Scores

In[ ]:=
```
complexity = AssociationThread @@ (ReverseSortBy[
       Table[{
         vertices[[x]]
         , VertexOutDegree[literals][[x]]}
        , {x, 1, Length[vertices]}]
       , Last
      ]
      // Transpose
   );
complexity // Dataset[#, ItemStyle → {Black}, HeaderStyle → Bold,
   HeaderBackground → LightYellow, MaxItems → (vertices // Length)] &
```

Out[ ]=

mining	11
issuance	8
coinbase tx	8
transaction	7
block reward	7
utxo	5
mining difficulty	5
mining diff adj	5
halving	5
change address	5
change	5
proof of work	4
mempool	4
blockchain	4
block	4
tx fee	3
transactions	3
block time	3
receive address	2
satoshi	1
hashing	1

Prerequisite minus Complexity Scores

In[ ]:=
```
ReverseSort[Merge[{prerequisites, -complexity}, Total]] //
 Dataset[#, ItemStyle → {Black}, HeaderStyle → Bold,
   HeaderBackground → LightYellow, MaxItems → (vertices // Length)] &
```

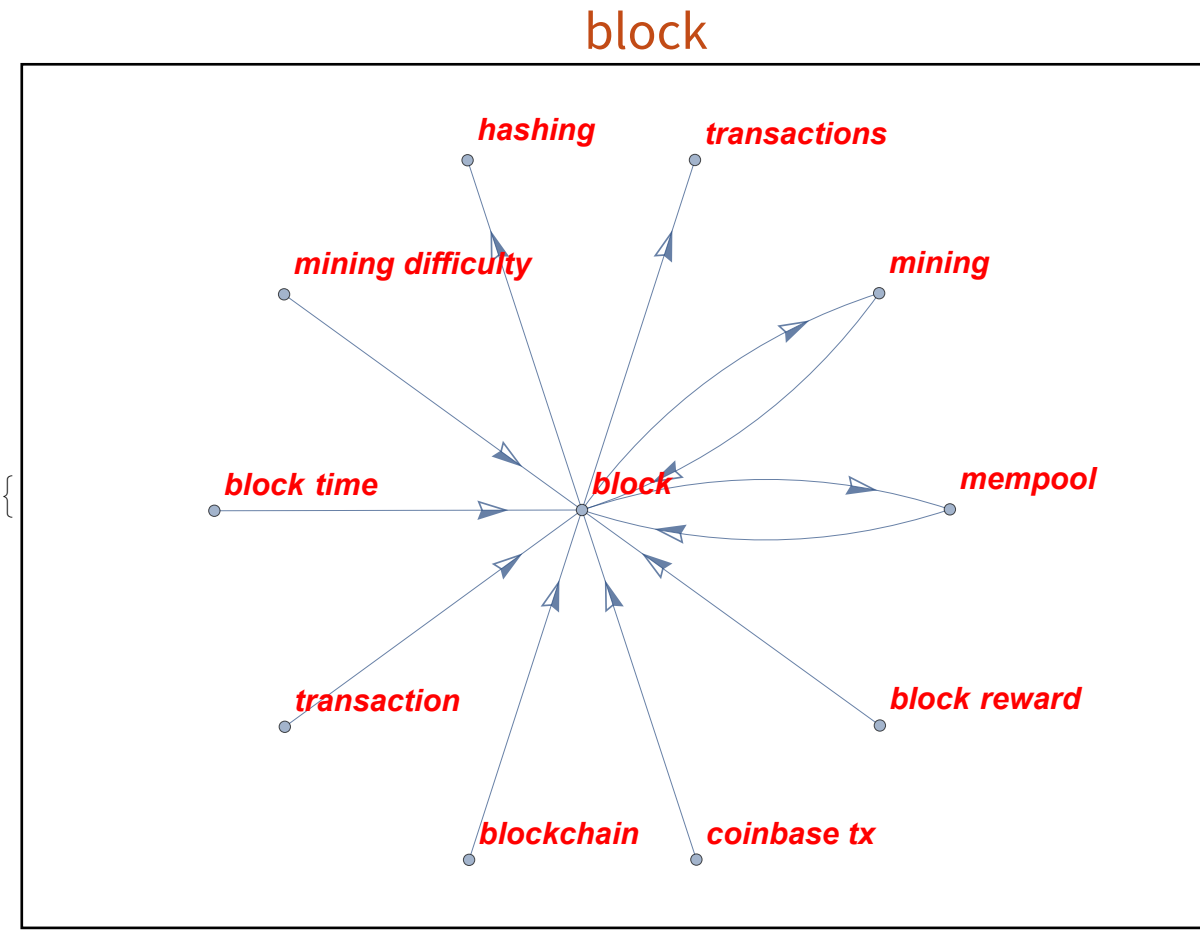
Out[ ]=

satoshi	7
hashing	5
block	4
proof of work	4
receive address	3
blockchain	3
block time	2
tx fee	2
transaction	1
transactions	0
mining difficulty	0
mempool	−1
utxo	−1
change	−2
mining	−2
change address	−3
mining diff adj	−3
block reward	−3
halving	−4
coinbase tx	−5
issuance	−7

Vertex views

In[ ]:=
```
Table[
 Labeled[
  Framed[
   Graph[
    Select[literals, #[[1]] == x || #[[2]] == x &]
    , ImageSize → {600, 400}
    , ImageMargins → 20
    , VertexSize → 0.05
    , VertexLabels → "Name"
    , VertexLabelStyle → Directive[Red, Italic, Bold, 16]
    , EdgeShapeFunction → {{"CarvedArrow", "ArrowSize" → .04}}
   ]
  ]
  , x
  , Top
  , LabelStyle → "Section"
 ]
 , {x, vertices}
]
```

Out[ ]=

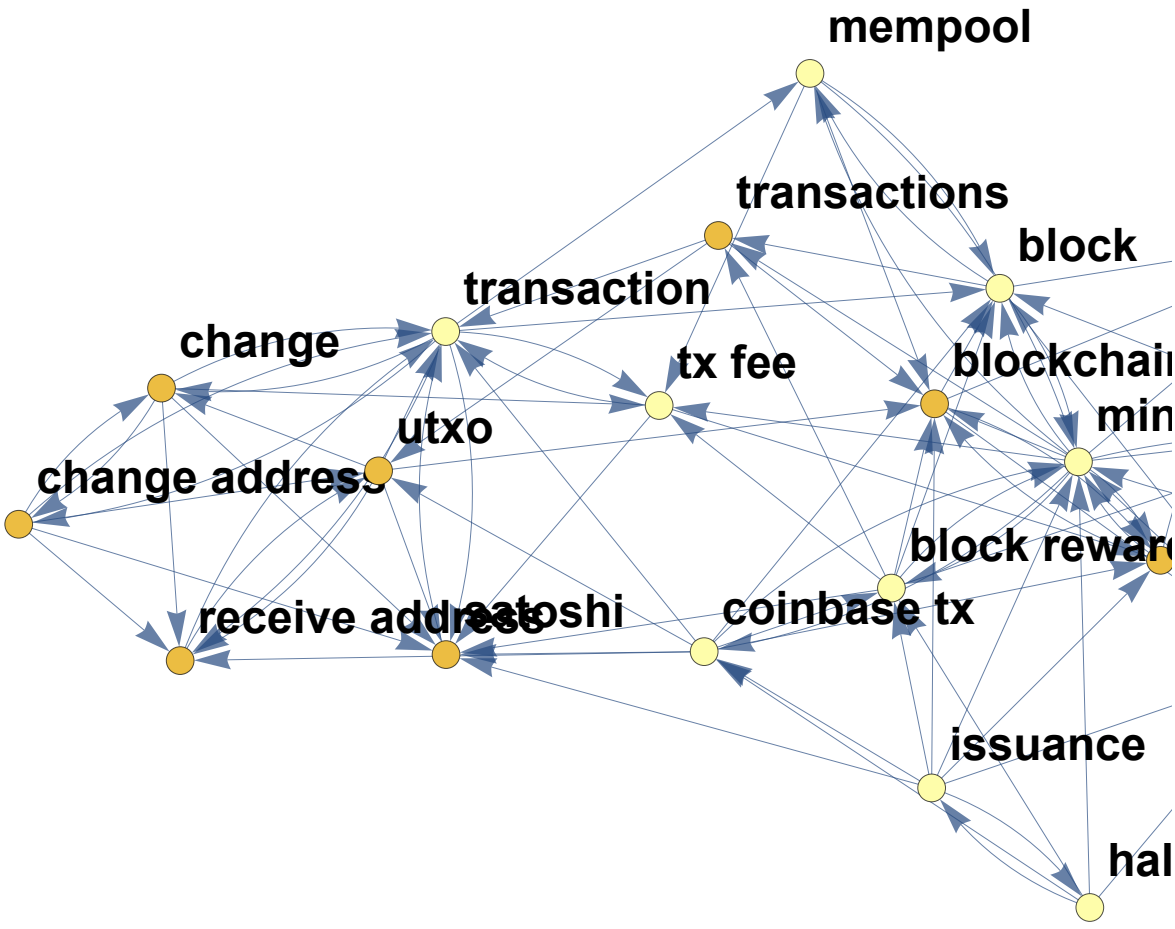


In[ ]:=
```
literals // Length
```

Out[ ]=
```
100
```

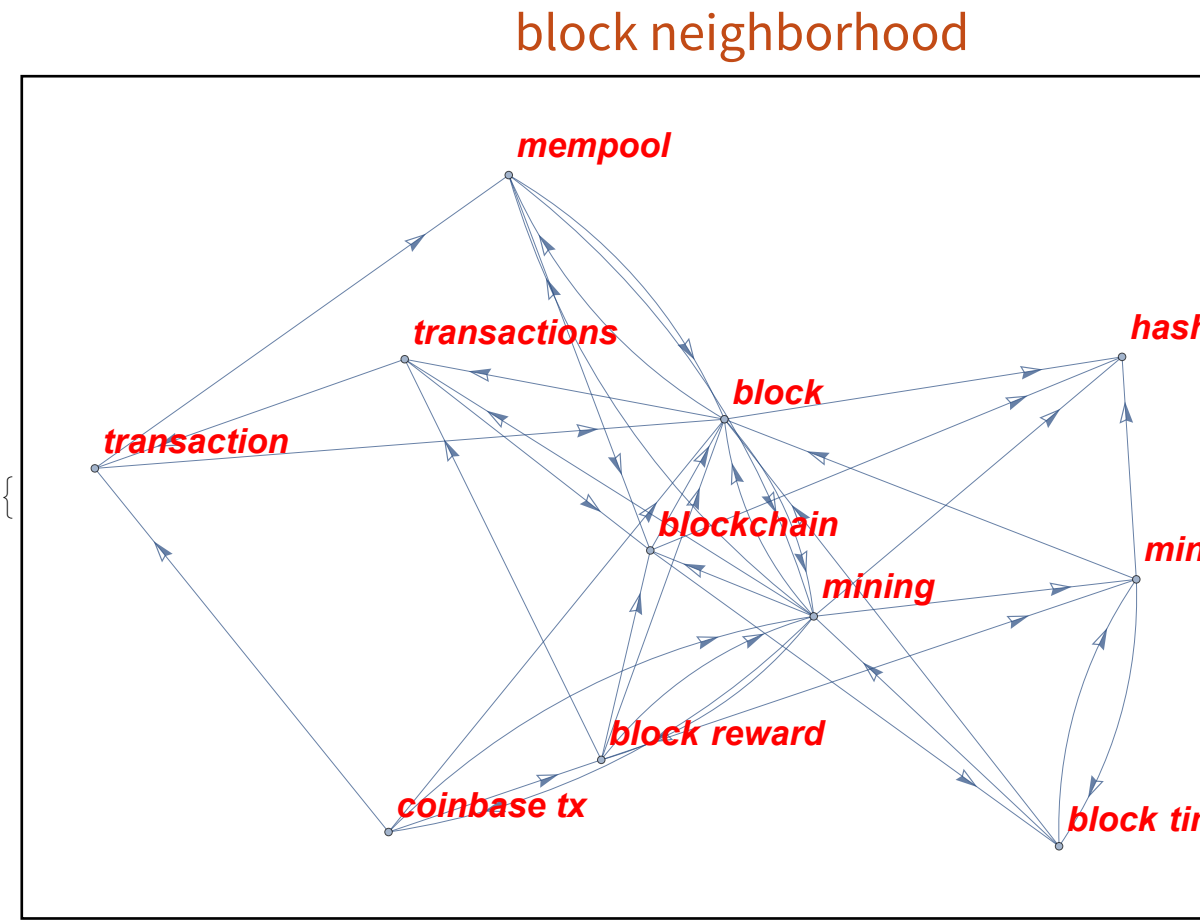
In[ ]:=
```
ve = Table[VertexEccentricity[literals, v], {v, vertices}];
HighlightGraph[literals, Table[
  Style[v, ColorData["TemperatureMap", ve[[VertexIndex[literals, v]]] / Max[ve]]],
  {v, vertices}], VertexLabels → "Name",
 VertexLabelStyle → Directive[Black, 24, Bold]]
```

Out[ ]=



In[ ]:=
```
Table[
 Labeled[
  Framed[
   NeighborhoodGraph[
    literals
    , x
    , ImageSize → 700
    , ImageMargins → 20
    , VertexSize → 0.05
    , VertexLabels → "Name"
    , VertexLabelStyle → Directive[Red, Italic, Bold, 18]
    , EdgeShapeFunction → {{"CarvedArrow", "ArrowSize" → .02}}
   ]
  ]
  , StringJoin[x, " neighborhood"]
  , Top
  , LabelStyle → "Section"
 ]
 , {x, vertices // Sort}
]
```

Out[ ]=



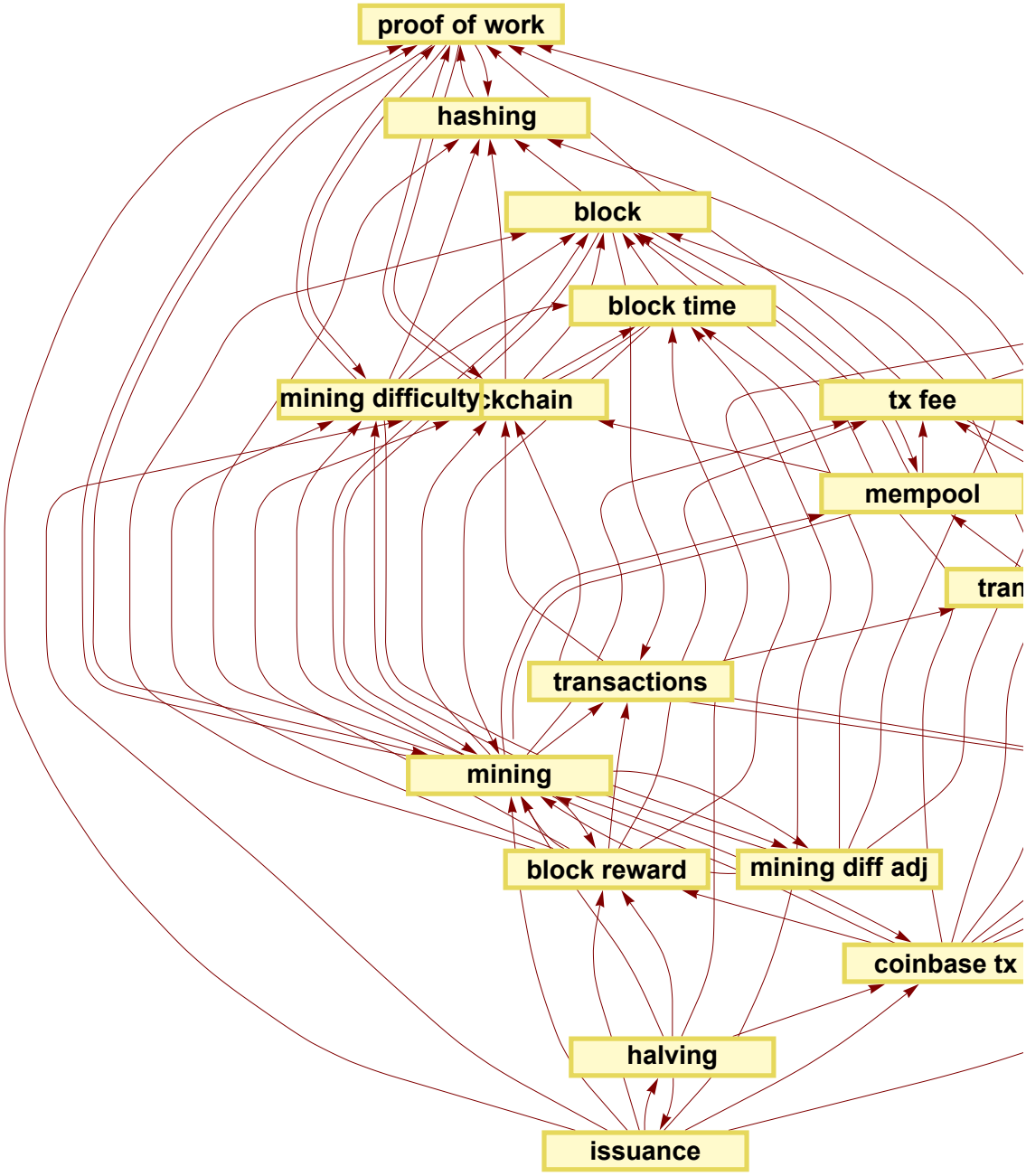
In[ ]:= `AssociationThread[VertexList[literals], VertexDegree[literals]] // ReverseSort`

Out[ ]=

```
⟨| mining → 20, transaction → 15, proof of work → 12,
 block → 12, coinbase tx → 11, block reward → 11, blockchain → 11,
 mining difficulty → 10, issuance → 9, utxo → 9, satoshi → 9, change → 8,
 tx fee → 8, block time → 8, mining diff adj → 7, receive address → 7,
 change address → 7, mempool → 7, hashing → 7, halving → 6, transactions → 6 |⟩
```

In[•]:=
```
LayeredGraphPlot[
 literals
 , Bottom
 , ImageSize → 900
 , ImageMargins → 20
 , VertexSize → {2.75, .5}
 , AspectRatio → 0.75
 , VertexLabelStyle → Directive[Bold, 15]
 (*,VertexSize→0.05
 , VertexLabels→"Name"
 ,EdgeShapeFunction→{{"CarvedArrow","ArrowSize"→.02}}
 *)
 , PlotTheme → "ClassicDiagram"
]
```

Out[ ]=


proof of work
hashing
block
block time
mining difficulty
ckchain
tx fee
mempool
tran
transactions
mining
block reward
mining diff adj
coinbase tx
halving
issuance