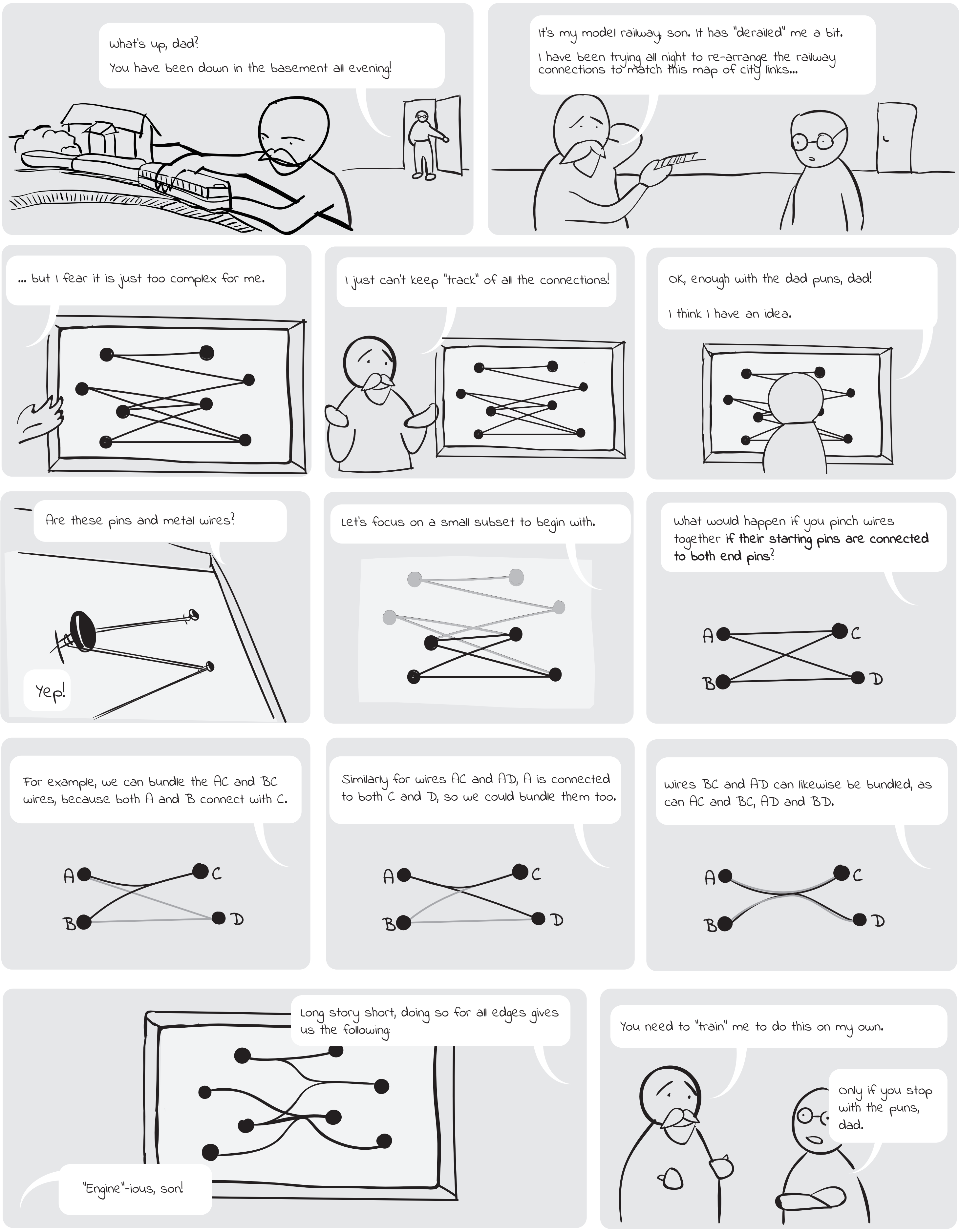
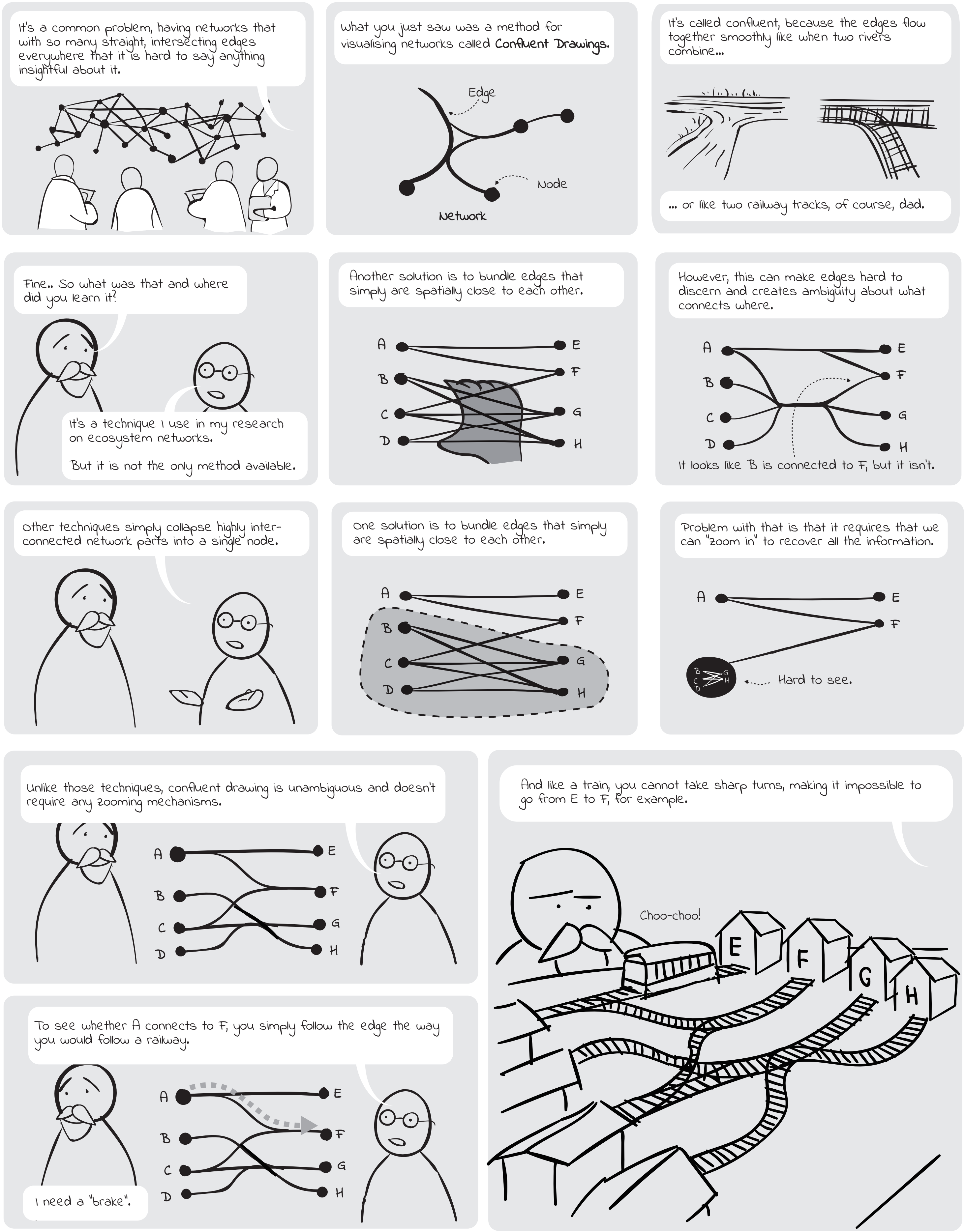
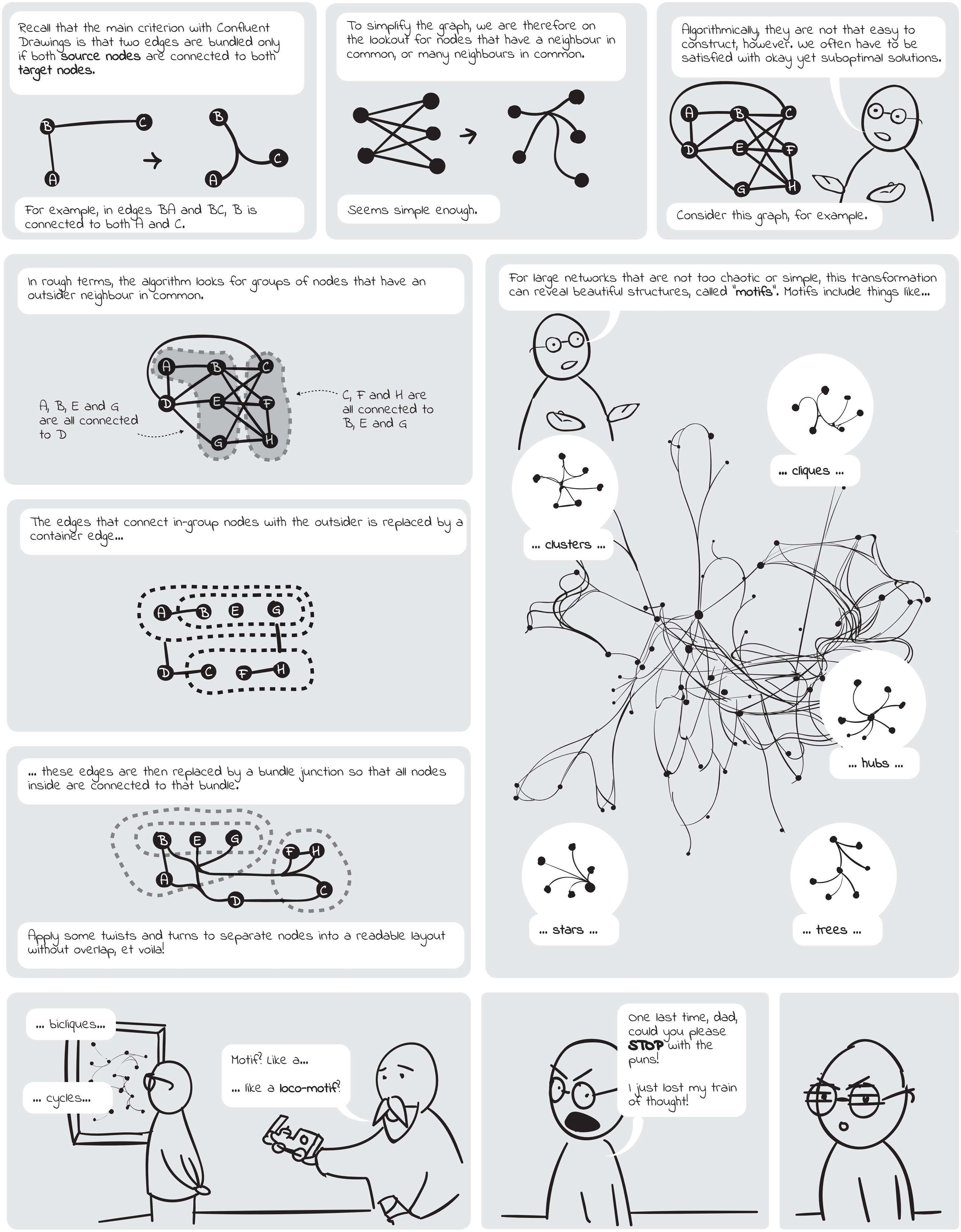
Confluence Graph

Introduction


What's up, dad?
You have been down in the basement all evening!
It's my model railway, son. It has "derailed" me a bit.
I have been trying all night to re-arrange the railway connections to match this map of city links...
... but I fear it is just too complex for me.
I just can't keep "track" of all the connections!
OK, enough with the dad puns, dad!
I think I have an idea.
Are these pins and metal wires?
Yep!
Let's focus on a small subset to begin with.
What would happen if you pinch wires together if their starting pins are connected to both end pins?
A
C
B
D
For example, we can bundle the AC and BC wires, because both A and B connect with C.
A
C
B
D
Similarly for wires AC and AD, A is connected to both C and D, so we could bundle them too.
A
C
B
D
Wires BC and AD can likewise be bundled, as can AC and BC, AD and BD.
A
C
B
D
Long story short, doing so for all edges gives us the following:
"Engine"-ious, son!
You need to "train" me to do this on my own.
Only if you stop with the puns, dad.


It's a common problem, having networks that with so many straight, intersecting edges everywhere that it is hard to say anything insightful about it.
What you just saw was a method for visualising networks called **Confluent Drawings.**
Edge
Node
Network
It's called confluent, because the edges flow together smoothly like when two rivers combine...
... or like two railway tracks, of course, dad.
Fine.. So what was that and where did you learn it?
It's a technique I use in my research on ecosystem networks.
But it is not the only method available.
Another solution is to bundle edges that simply are spatially close to each other.
A
B
C
D
E
F
G
H
However, this can make edges hard to discern and creates ambiguity about what connects where.
A
B
C
D
E
F
G
H
It looks like B is connected to F, but it isn't.
Other techniques simply collapse highly inter-connected network parts into a single node.
One solution is to bundle edges that simply are spatially close to each other.
A
B
C
D
E
F
G
H
Problem with that is that it requires that we can "zoom in" to recover all the information.
A
E
F
B
C
D
G
H
Hard to see.
Unlike those techniques, confluent drawing is unambiguous and doesn't require any zooming mechanisms.
A
B
C
D
E
F
G
H
To see whether A connects to F, you simply follow the edge the way you would follow a railway.
A
B
C
D
E
F
G
H
I need a "brake".
And like a train, you cannot take sharp turns, making it impossible to go from E to F, for example.
Choo-choo!
E
F
G
H


Recall that the main criterion with Confluent Drawings is that two edges are bundled only if both **source nodes** are connected to both **target nodes.**
For example, in edges BA and BC, B is connected to both A and C.
To simplify the graph, we are therefore on the lookout for nodes that have a neighbour in common, or many neighbours in common.
Seems simple enough.
Algorithmically, they are not that easy to construct, however. We often have to be satisfied with okay yet suboptimal solutions.
Consider this graph, for example.
In rough terms, the algorithm looks for groups of nodes that have an outsider neighbour in common.
A, B, E and G are all connected to D
C, F and H are all connected to B, E and G
The edges that connect in-group nodes with the outsider is replaced by a container edge...
... these edges are then replaced by a bundle junction so that all nodes inside are connected to that bundle.
Apply some twists and turns to separate nodes into a readable layout without overlap, et voila!
For large networks that are not too chaotic or simple, this transformation can reveal beautiful structures, called "**motifs**". Motifs include things like...
... clusters ...
... cliques ...
... hubs ...
... stars ...
... trees ...
... bicliques...
... cycles...
Motif? Like a...
... like a **loco-motif**?
One last time, dad, could you please **STOP** with the puns!
I just lost my train of thought!

* Learn more about the algorithm:
Bach, B., Henry Riche, N., Hurter, C., Marriott, K, & Dwyer, T. (2017, January). Towards Unambiguous Edge Bundling: Investigating Confluent Drawings for Network Visualization. In IEEE Transactions on Visualization and Computer Graphics (Vol. 23, No. 1, pp. 693-716).