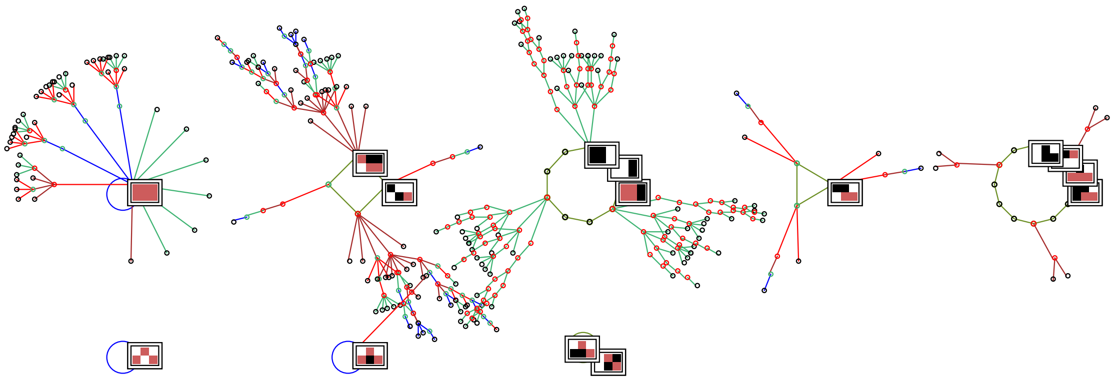

Figure 4.2: The basin of attraction field of multi-value $v3k3$ n=6 1d CA. The lookup table is 120201201020211201022121111 (1886122584a655 in hex). Just the 8 nonequivalent basins are shown from a total of 23, and attractor non-equivalent states are shown as 2d patterns. State-space=v^n=3^6=729. Note that the overlap can be fixed with layout options (chapter 25 or section 20.14).

4.2.3 Interactive basin of attraction field — ibaf-graph

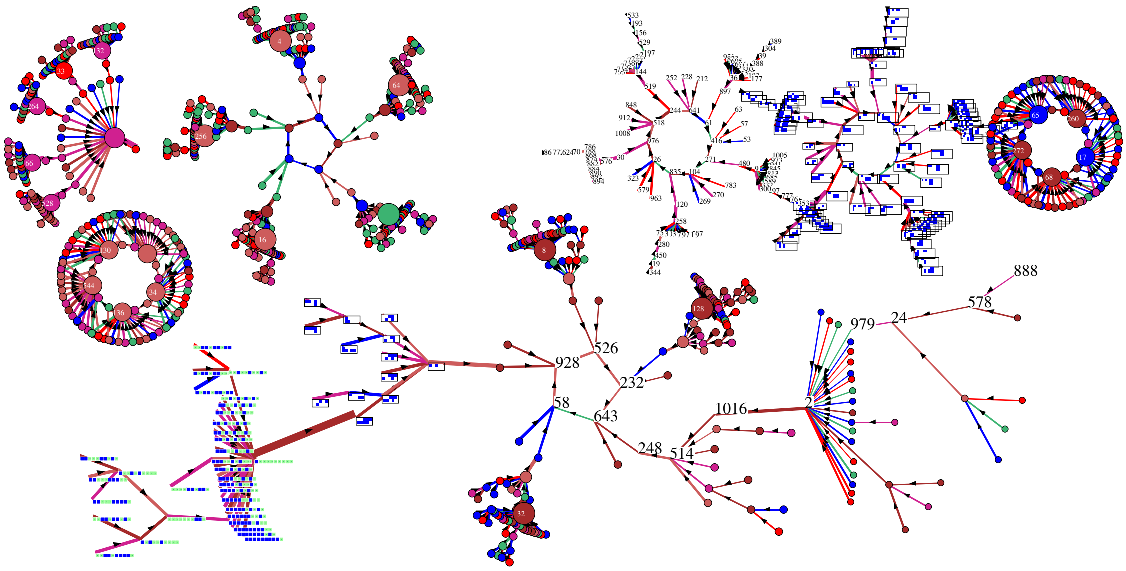

Figure 4.3: An ibaf-graph of a binary 1d CA, $v2k3$, n=10, rule 9 with 7 basins, The basin of attraction field as in figure 4.1, but uncompressed, was transformed to its ibaf-graph, initially with scaled nodes/links. Nodes were relabelled in basins 4 (decimal) and 5 (2d patterns). The 3rd basin was dragged lower, expanded, and some fragments were dragged and relabelled in decimal, 1d, and 2d. Note the sequence of decimal nodes starting at 888 (top right) which follow output arrows leading to the attractor.

The ibaf-graph (chapter 20, section 20.6) allows rearranging an uncompressed basin of attraction field computed with the exhaustive algorithm. Nodes and their attached "fragments" or whole components (basins) can be dragged, rescaled and relabelled according to "inputs/outputs/either" and a time-step distance, where "nolimit" combined with "either" captures a whole basin. Node labels within a fragment can be toggled between discs/decimal/hex/1d/2d/none.

To produce and rearrange an ibaf-graph like figure 4.3, proceed as follows,

1. From the first prompt keep accepting defaults with **return** or the left mouse button (about 9 presses), until the **Select v2k3 rcode** appears. then enter **d**.
2. At the next **decimal equivalent** prompt enter **9** to select the CA rule.
3. Enter **return** (about 3 presses) until the top-center **basin parameters** banner appears, and a top-right window with a list of options starting with **accept all basin defaults**. Enter **g** to select graphs.
4. At the next top-right **graphs** prompt enter **i** for the ibaf-graph, then **return** at the **compression OFF** reminder.
5. Then enter **return** (about 3 presses) until a **basin field** top-right prompt appears (just before drawing basins).Enter **e** for the exhaustive algorithm (section 29.7) which is required for the ibaf-graph.
6. At the next **exhaustive pairs** prompt enter **return** — the usual basin of attraction field will be drawn with the default layout, or with any changes made in section 4.2.2.
7. When drawing is complete, **ibaf-i** appears below the green progress bar, enter **i** — the ibaf-graph will be computed and drawn with the same layout above.
8. Once complete, the top-right initial options reminder appears — these apply to all nodes/links in ibaf-graph simultaneously — for decode see section 20.9.

   IBAF-graph: drag-(def) PScript-P net-# ant-a unscram-u win-w rank0-k
   settings-S rot-x/X flip-h/v nodes-(/)/= links-{/} both-[/]
   Unreach-U matrix-t/T nodes-n/N links-l Labels-+ arrows-A/</>
   layout: file-f graph-g circle/spiral-o/O 1d/2d(tog)/3d-1/2/3 rnd-r/R quit-q:

9. Click the left mouse button (or enter **return**) for the drag-options, then click the center of a node (a right click may also be required initially) to lock-on/activate — so its number appears in the drag reminder — then drag the active node and its connected fragment with the mouse pointer (button depressed) to another position, then release. The drag options apply to fragments and components (basins) rooted on the active node. (see section 20.4),

   node 0, eather, step=nolimit: drag-leftb PScript-P elstc/snap-d gap-g
   not active?-rightb first, rot-x/X flip-h/v nodes-(/)= links-{/} both-[/] just-j
   Lnk0:cut/restore-c/r Lnks0-0:cut/add/restore-C/A/R net-#
   step-(1-9) nolimit-0 single-s in/out/either-i/o/e all-a exit-q:

The drag-option reminder is context dependent (explained in depth in section ??) — options mostly work immediately by keyhits — try the following to rearrange the ibaf-graph as in figure 4.3,

i/o/e . . . for "inputs", "outputs" or "either", which defines the direction of links in the fragment — "**e**" for "either" is the starting default.

nolimit-0 . . . enter "**0**" (zero — the starting default) for "nolimit" to the distance of connected time-steps from the active node. When combined with "either" above, the fragment will capture the whole basin.

step-(1-9) . . . enter **1** or a number up to **9** to limit the distance in time-steps, the reach of the fragment from the active node — for dragging, relabelling, and to contract/expand nodes/links.

nodes-(/)= . . . use round brackets — **(** to contract, **)** to expand, the size of nodes, enter the equal sign "**=**" to toggle nodes display between discs/decimal/hex/1d/2d/none.

links-{/} . . . use curly brackets — "**{**" to contract, "**}**" to expand, the length of links — the distance between nodes.

both-[/] . . . use square brackets — "[" to contract, "]" to expand, the size of nodes and links at he same time.

single-s . . . enter "**s**" to restrict changes to the active node only — some options in the drag reminder will change.

just-j . . . enter "**j**" to isolate the basin with the active node, hiding other basins. Enter "**j**" again to restore.

elstc/snap-d . . . enter "**d**" to toggle "drag" between elastic/snap. Elastic drag is the default, but **snap**, where just the active node is dragged, then its fragment snaps into place, is nore efficient for a larger ibaf-graph.

exit-q . . . to return to the initial options. The revised layout is kept but "**graph-g**2 restores the original.

4.3 Backwards space-time patterns, and state-space matrix

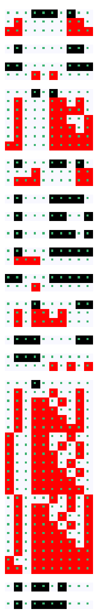

Figure 4.4: Backwards space-time patterns relating to the basin of attraction field of the v=2 CA in figure 4.1. Space across, time top down. The red and white bit patterns are the predecessors of black and white bit patterns.

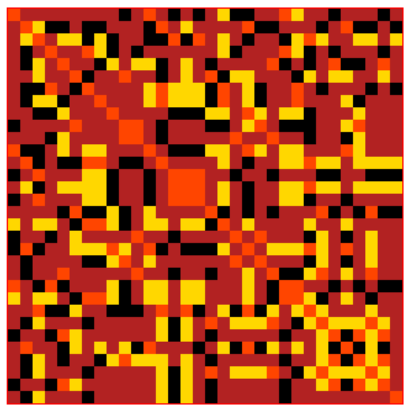

Figure 4.5: The state-apace matrix represents state-space, plotting the left half of each state bitstring against the right half. Colors represent different basins of attraction in figure 4.1.

While the attractor basins are generating, various display settings, indicated in the bottom title bar, can be changed on-the-fly. However, basins may generate too fast to intervene on-the-fly. In this case, at the pause when a basin is complete, enter **s** for **speed** in a top-left window, and follow self-explanatory prompts to slow down. Alternatively, backtrack to slightly increase n, v or k.

1. Enter **s** to toggle the "backwards" space-time pattern on-off, and see predecessors (pre-images) being generated on the left of the screen (figure 4.4). Initially the attractor states