# Sudoku Players' Forums

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# The concept of a RESOLUTION RULE and its applications

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|---|---|
| **denis_berthier** | Posted: Fri Nov 14, 2008 11:30 pm Post subject: |

Joined: 19 Jun 2007
Posts: 1122
Location: Paris, France

> **re'born wrote:**
>
> > **Denis wrote:**
> >
> > I've mentioned other possibilities of using two nrczt-chains, here http://www.sudoku.com/boards/viewtopic.php?t=5591&postdays=0&postorder=asc&start=120
> > It is very inefficient. I can't prove this formally but I've tried.
>
> Thank you, Denis. Until I see evidence to the contrary, I'll take your word for it.

There's another possibility: you can try to find examples such that there's no chain no longer than the sum of the lengths of the two chains and allowing the same elimination.
You'll see at least how hard it is to deal with two chains at the same time.

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|---|---|
| **re'born** | Posted: Sat Nov 15, 2008 12:41 am Post subject: |

Joined: 31 May 2007
Posts: 552
Location: Wilmington, MA

> **denis_berthier wrote:**
>
> > **re'born wrote:**
> >
> > > **Denis wrote:**
> > >
> > > I've mentioned other possibilities of using two nrczt-chains, here http://www.sudoku.com/boards/viewtopic.php?t=5591&postdays=0&postorder=asc&start=120
> > > It is very inefficient. I can't prove this formally but I've tried.
> >
> > Thank you, Denis. Until I see evidence to the contrary, I'll take your word for it.

> There's another possibility: you can try to find examples such that there's no chain no longer than the sum of the lengths of the two chains and allowing the same elimination.
> You'll see at least how hard it is to deal with two chains at the same time.

For me, chain length was never a very reliable measure of how difficult it was to find. Incidentally, have you read Bud's **recent post**? He is combining chains in a different way in a simple case: 2 xy-wings.

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**denis_berthier**

Joined: 19 Jun 2007
Posts: 1122
Location: Paris, France

Posted: Sat Nov 15, 2008 1:02 am Post subject:

**re'born wrote:**
> For me, chain length was never a very reliable measure of how difficult it was to find.

Not reliable in the absolute, I agree. But very meaningful statistically (see the "rating rules" thread: http://www.sudoku.com/boards/viewtopic.php?t=5995)

**re'born wrote:**
> Incidentally, have you read Bud's **recent post**? He is combining chains in a different way in a simple case: 2 xy-wings.

Thanks for the reference. I'll have a look.
Trying to combine simple patterns into new ones may be interesting **if** it leads to eliminations that weren't available by a mere application of these patterns and of other more basic rules.
The problem is different with longer chains: complexity is squared.

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**re'born**

Joined: 31 May 2007
Posts: 552
Location: Wilmington, MA

Posted: Sat Nov 15, 2008 4:20 am Post subject:

**denis_berthier wrote:**
> **re'born wrote:**
> > For me, chain length was never a very reliable measure of how difficult it was to find.
>
> Not reliable in the absolute, I agree. But very meaningful statistically (see the "rating rules" thread: http://www.sudoku.com/boards/viewtopic.php?t=5995)

Yes, I can see why it is a natural way for you to break up chains (in terms of cataloging). For the manual solver, the difficulty of finding certain chains depends only vaguely on length, e.g., chains such that consecutive candidates form a conjugate pair, remote naked pairs, xy-chains or extended w-wings.

**re'born wrote:**

> Incidentally, have you read Bud's **recent post**? He is combining chains in a different way in a simple case: 2 xy-wings.

**Denis wrote:**

> Thanks for the reference. I'll have a look.
> Trying to combine simple patterns into new ones may be interesting **if** it leads to eliminations that weren't available by a mere application of these patterns and of other more basic rules.

For a computer, probably. For a manual solver, it isn't as clear cut. Start with a puzzle whose difficulty is unknown. As you begin solve it, you notice an xy-wing, make the elimination and move on. Later, you go post your solution and udosuk informs you it could be solved with singles. Should I have taken the xy-wing move?

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**denis_berthier**

Joined: 19 Jun 2007
Posts: 1122
Location: Paris, France

Posted: Sat Nov 15, 2008 4:34 am Post subject: quote edit

**re'born wrote:**

> For the manual solver, the difficulty of finding certain chains depends only vaguely on length, e.g., chains such that consecutive candidates form a conjugate pair, remote naked pairs, xy-chains or extended w-wings.

The manual sover has to find useful chains amo,ng lots of useless ones. He is no better at this than the computer.

**re'born wrote:**

> For a manual solver, it isn't as clear cut. Start with a puzzle whose difficulty is unknown. As you begin solve it, you notice an xy-wing, make the elimination and move on. Later, you go post your solution and udosuk informs you it could be solved with singles. Should I have taken the xy-wing move?

Any move you take is OK.
But the problemis: how likely is this example?

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**re'born**

Joined: 31 May 2007
Posts: 552
Location: Wilmington, MA

Posted: Sat Nov 15, 2008 12:45 pm Post subject: quote

**denis_berthier wrote:**

> **re'born wrote:**
>
> > For a manual solver, it isn't as clear cut. Start with a puzzle whose difficulty is unknown. As you begin solve it, you notice an xy-wing, make the elimination and move on. Later, you go

> > post your solution and udosuk informs you it could be solved with singles. Should I have taken the xy-wing move?
>
> Any move you take is OK.
> But the problemis: how likely is this example?

Well, I won't speak for other solvers, but for me this particular scenario happens consistently if I'm in the mood to look at bivalue cells. Replace xy-wing with x-wing, however, and it becomes better than even money. Replace x-wing with locked candidates and it's a mortal lock.

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**denis_berthier**

Joined: 19 Jun 2007
Posts: 1122
Location: Paris, France

Posted: Sat Nov 15, 2008 9:22 pm Post subject: quote edit

**re'born wrote:**

> Incidentally, have you read Bud's **recent post**? He is combining chains in a different way in a simple case: 2 xy-wings.

Nothing really new. No new elimination: sequence of 2 xy-wings and an xy-chain.

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**aran**

Joined: 02 Mar 2007
Posts: 454

Posted: Mon Nov 17, 2008 11:44 am Post subject: quote

**Denis**

**Quote:**

> aran wrote:
>
> Let (a,b) be an ordered cell source cell for xyt chain A.
> Then (b,a) is an ordered cell from which there may be an xyt chain B different from A.
> Whatever the length of A, and whatever the length of B, each and every right hand link of A is strongly linked to each and every right hand link of B.
>
> Completely absurd.

It's a few days back, but in the interval I hope it has dawned that the absurd party wasn't the one being targeted...

**Re'born** : this is the real Aran speaking :) ...wrote

**Quote:**

> If you have an xyt-chain (a b) - ... - (w x) (where (w x) might be modulo some t-candidates)
> and if you have another xyt-chain (b a) - ... - (y z) (where, again, (y z) might be modulo some t-candidates),
> then we can read the first chain as saying if a is not true, then x is true and the second as saying if b is not true then z is true. Since a or b is true, we conclude x or z is true, i.e., x is strongly linked to z.
>
> Aran, is this what you are saying?

I am saying that but more than that.
**All** of the right-hand links in the ordered cells in the respective xyt chains (starting from cell C respectively ordered (a,b) and (b,a)) are strong-linked : not merely the final cell.
Think of it in terms of transport : each of the right-hand links in the starting cell ie b for (a,b) and a for (b,a) is in effect transported by the xyt chain (remembering that the "backward-looking" t candidates by virtue of their seeing preceding "truths" in the chain do not hinder chain progression).
Then each T (as in Truth) in the first chain is strong-linked to each T in the second.
This generates multiple strong-links.
What I was saying (and Denis seems unable to see this point) is that within his own system, if he wants it to be efficient, or less inefficient, he could easily (ie for little extra work) examine these links for possible eliminations.
Note that eliminations found in this way might not necessarily be found by any xyt chain examined singly. One cannot in fact say at what point they would emerge in that system.

As to the example I gave, it is entirely well-founded.
Here it is again :
Suppose that P and Q are nrc-linked cells in the respective chains.
Say the ordered cells are P (257) and Q (1345) (ie t candidates 5 and 34)
=>7P 5Q strongly linked
=>given the nrc-link : P <5>.
Thus whether or not there was a z elimination, there is a t elimination in this example.

(Apparently I'm misusing "nrc-linked" which in any case just means "sees")
So P and Q see each other and are in the respective chains.
Therefore their right-hand links (or "True" candidates) are strongly-linked.
Hence either 7 is true in P or 5 in Q or both, and whatever, 5 must be eliminated from P.
In this example, it so happens that a "t" candidate is eliminated.

I did not say and am not saying that there will necessarily be t eliminations, nor indeed any eliminations.
If I used the "t" elimination in my example it was to illustrate the curiosity of setting out to target "z" eliminations (plural because of both chains) and ending up...paradoxically... with a "t" one.

Of course, a second type of possible elimination arises where the respective right-hand links are strongly linked on the same candidate, say w. In this case any w seen by both is eliminated (which does not impose the condition that the strong-link candidates see each other).

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**denis_berthier** Posted: Mon Nov 17, 2008 9:28 pm Post subject: quote edit

**Aran**,

Joined: 19 Jun 2007
Posts: 1122
Location: Paris, France

In my framework, a rule asserts value(s) and eliminates candidate(s). There's no intermediate goal of computing all the possible indirect "strong links".
If you want to propose a new rule that asserts "strong links" or that eliminates t-candidates, based on some combination of xyzt or nrczt chains, and dealing with notions completely alien to my framework, such as "strong links", I suggest you open a new thread for this.
We're eager to learn about efficiency matters from you.

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**re'born**

Joined: 31 May 2007
Posts: 552
Location: Wilmington, MA

Posted: Tue Nov 18, 2008 4:26 am    Post subject:

**aran wrote:**

> I am saying that but more than that.
> **All** of the right-hand links in the ordered cells in the respective xyt chains (starting from cell C respectively ordered (a,b) and (b,a)) are strong-linked : not merely the final cell.

I think we're on the same page. My view of an xyt-chain is that you can remove the last cell and it remains an xyt-chain. Therefore, what you said is an immediate consequence of what I said.

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**aran**

Joined: 02 Mar 2007
Posts: 454

Posted: Tue Nov 18, 2008 8:19 am    Post subject:

**Re'born**

**Quote:**

> aran wrote:
>
> I am saying that but more than that.
> All of the right-hand links in the ordered cells in the respective xyt chains (starting from cell C respectively ordered (a,b) and (b,a)) are strong-linked : not merely the final cell.
>
> I think we're on the same page. My view of an xyt-chain is that you can remove the last cell and it remains an xyt-chain. Therefore, what you said is an immediate consequence of what I said.

Indeed you are right.

**Denis**

**Quote:**

> Aran,
> In my framework, a rule asserts value(s) and eliminates candidate(s). There's no intermediate goal of computing all the possible indirect "strong links".
> If you want to propose a new rule that asserts "strong links" or that eliminates t-candidates, based on some combination of xyzt or nrczt chains, and dealing with notions completely alien to my framework, such as "strong links", I suggest you open a new thread for this

The rule doesn't eliminate candidates de nihilo : patterns aren't identified without being looked for, and any eliminations arising result from strong links at the chain ends. Even if you don't give them a name nor refer to them.

> **Quote:**
> We're eager to learn about efficiency matters from you.

I know this is well meant so here is a point to be going on with :
E1 : Efficiency of Presentation.
Present all your eliminations in rc-space regardless of what space you found them in.
Benefits : make your work accessible to a wider public.

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**denis_berthier**

Joined: 19 Jun 2007
Posts: 1122
Location: Paris, France

Posted: Wed Nov 19, 2008 3:27 am    Post subject: | quote | edit

> **aran wrote:**
>> **Quote:**
>> Aran,
>> In my framework, a rule asserts value(s) and eliminates candidate(s). There's no intermediate goal of computing all the possible indirect "strong links".
>> If you want to propose a new rule that asserts "strong links" or that eliminates t-candidates, based on some combination of xyzt or nrczt chains, and dealing with notions completely alien to my framework, such as "strong links", I suggest you open a new thread for this
>
> The rule doesn't eliminate candidates de nihilo : patterns aren't identified without being looked for

Of course, you have to look for patterns. There's no miracle. But, in my approach, you don't have to look for all the possible indirect "strong links" independently of patterns (Pairs, chains, whips, ...) in which you know in advance they will be useful. That's all the difference with what you were suggesting.

> **aran wrote:**
> Present all your eliminations in rc-space regardless of what space you found them in.

AFAIK, that's what I do. I always write an elimination "=> rc <> n", as everybody.

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**denis_berthier**

Posted: Wed Dec 10, 2008 7:16 pm    Post subject: | quote | edit

Joined: 19 Jun 2007
Posts: 1122
Location: Paris, France

**FROM CONSTRAINTS TO RESOLUTION RULES**

Many real world problems, such as resource allocation, temporal reasoning or scheduling, naturally appear as constraint satisfaction problems (CSP). Constraints satisfaction is a main sub-area of Artificial Intelligence.

A finite CSP is defined by a finite number of variables with values in some fixed finite domains and a finite set of constraints (i.e. of relations they must satisfy); it consists of finding a value for each of these variables, such that they globally satisfy all the constraints. It can be formulated as a First Order Logic (FOL) theory.

Sudoku is obviously a CSP. The "natural" variables are the Xrc (one variable for each row r and each column c), with range the set of numbers {1 2 3 4 5 6 7 8 9} that can occupy these cells; but it is convenient to add auxiliary variables Xbs, Xrn, Xcn, Xbn to take into account the natural symmetries and super-symmetries of the problem.

Variants of Sudoku are CSPs and so are many other "logic games".

Most of what I have done for Sudoku can be extended to any finite CSP:

* the whole general conceptual framework in Multi-Sorted First Order Logic (MS-FOL);
* definition of candidates and elaboration of their logical epistemic status;
* definition of candidates being linked by a direct contradiction or simply "linked" (what I've called "nrc-linked" in Sudoku);
* definitions of a resolution rule, a resolution theory, the constructive solution of a CSP according to a resolution theory, a resolution strategy;
* definition of a chain and a target;
* definition of a bivalue variable and a bivalue chain (which corresponds to an xy-chain or to an nrc-chain, depending on which set of variables we take as primitive);
* definitions of t-, z- and zt- chains, whips and braids;
* proof of the zt- chain, whip and braid elimination theorems;
* proof of the confluence property for naturally defined zt-braid resolution theories;
* proof of the T&E vs zt-braids elimination theorem.

Details can be found in two presentations I've done at the CISSE'08 conference (http://www.cisse2008online.org).
pdf preprints of the associated papers can be found on my Web pages dedicated to Sudoku: http://www.carva.org/denis.berthier/HLS (permanent URL).

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**denis_berthier**

Joined: 19 Jun 2007
Posts: 1122
Location: Paris, France

Posted: Thu Dec 31, 2009 9:07 am Post subject:

quote edit

I have recently updated the part of my website related to Sudoku (http://www.carva.org/denis.berthier/HLS)

Main changes:
<> as it was initially only a quick compilation of my posts in this forum, it may still reflect this but it is now more self-contained;
<> the index page now contains short descriptions of what the other pages are about; it should make it easier to find what you are looking for;
<> most of the examples are now in the strict nrc-notation instead of the sloppy one;
<> generalised whips and braids - whips(FP) and braids(FP) - have now moved to the zt-ing page instead of the basic nrczt-whips and nrczt-braids pages; this better reflects the way I consider them: useful only for exceptionally hard puzzles.

I hope I have broken no link, but if you find one, thanks in advance for signalling.

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**denis_berthier**

Joined: 19 Jun 2007
Posts: 1122
Location: Paris, France

Posted: Thu Jan 07, 2010 7:29 am Post subject:

quote edit

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**BACK TO THE CONFLUENCE PROPERTY**

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I have been busy with other things and I have neglected to speak of the confluence property for a long time. But it is now time for a summary of all that I can say about it.

Confluence is a very important (both theoretical and practical) property of a resolution theory T (i.e. a fixed set of resolution rules).
In practice, and this may be the best way for players to consider it informally, it guarantees that one can apply the resolution rules in T in any order without changing the final state that can be reached within this theory. In particular, if a puzzle can be solved within T, the confluence property of T guarantees that one can find this solution in an opportunistic way, e.g. by applying the rules in T as soon as one finds the corresponding patterns.
More generally, it allows to consider various formalised resolution strategies using the rules in T.

**0) FORMAL DEFINITION**
***A resolution theory T has the confluence property if, for any puzzle P and any two knowledge states KS1 and KS2 for P, there is a knowledge state KS3 such that KS3 can be reached independently from both KS1 and KS2 using only resolution rules from T.***

(A knowledge state is the formal counterpart of a PM).
Said otherwise: for any puzzle P, the set of knowledge states for P, ordered by the reachability relation defined by T, is a DAG (Directed Acyclic Graph).

Let me now introduce a new property, a priori stronger than confluence.
***Definition: a resolution theory T is stable for confluence if for any puzzle P, for any knowledge state KS for P and for any resolution rule R from T applicable in state KS and leading to an elimination X, if any elimination Y is done before applying R and if this elimination destroys the pattern of R (which can therefore no longer be applied), then after Y is done, there is another rule in T that can be applied to eliminate X.***
(In this definition, the elimination Y is not necessarily done by a rule from T).

It is obvious that: ***T is stable for confluence => T has the confluence property.***

What's interesting here is the following (obvious):
***Theorem: Let T1 and T2 be two resolution theories. If T1 and T2 are stable for confluence, the union of T1 and T2 is stable for confluence (and has therefore the confluence property).***

**1) SUBSET THEORIES**

Let me recall the definitions of these theories.

Definition: let Subsetn be the following sets of resolution rules:
Subset0: ECP (elementary constraints propagation) (no unsolved puzzle can be solved here)
Subset1_0: Naked and Hidden Singles
Subset1: rules for elementary row-block and column-block interactions - see the subsumption page)
Subset2: Naked, Hidden and Super-Hidden Pairs
Subset3: Naked, Hidden and Super-Hidden Triplets
Subset4: Naked, Hidden and Super-Hidden Quads

Remarks:
- Super-Hidden = Fish
- Pairs, Triplets and Quads are always considered as non-degenerate.

Definition: for each n = 0, 1_0, 1, 2, 3, 4, the resolution theory Tn(Subset) is the set of resolution rules at Subsetn levels from 0 to n, i.e. Tn(Subset) = Subset0 + Subset1_0 + ... + Subsetn.

The situation for subset theories is very simple: **all the subset resolution theories Tn(Subset) have the confluence property and are stable for confluence**. The proof is obvious.

**2) NRCZT-BRAID THEORIES**

The situation for braids is very simple: **all the braid resolution theories I have defined have the confluence property and are stable for confluence**.

**2.1) pB-NRCZT theories**
Definition: let pB-NRCZTn be the following sets of resolution rules:
pB-NRCZT0: ECP (elementary constraints propagation) (no unsolved puzzle can be solved here)
pB-NRCZT1_0: Naked and Hidden Singles
pB-NRCZT1: rules for nrczt-braids of length 1 (equivalent to elementary row-block and column-block interactions - see the subsumption page)
....
pB-NRCZTn : rules for nrczt-braids of length n.

Remember that the length of a braid is the number of rc, rn, cn or bn cells on which it resides.

Definition: for each each n ≥ 0, the resolution theory Tn(pB-NRCZT) is the set of resolution rules at pB-NRCZT levels from 0 to n, i.e. Tn(pB-NRCZT) = pB-NRCZT0 + pB-NRCZT1_0 + pB-NRCZT1 + ... pB-NRCZTn.

I have shown here hhtp://wwww.carva.org/denis.berthier/CISSE08-CSP-P2.pdf that all these Tn(pB-NRCZT) theories have the confluence property. Indeed, the proof shows that these theories are stable for confluence.

The **pB-NRCZT rating** of a puzzle P is defined as the smallest n such that P can be solved within Tn(pB-NRCZT). A puzzle P has pB-NRCZT rating n if it can be solved using only braids of length no more than n but it cannot be solved using only braids of length strictly smaller than n.
The pB-NRCZT rating has therefore all the good properties one can expect of a rating:
- it is defined in a purely logical way, independent of any solver;
- it is invariant under symmetry and supersymmetry;
- it is based on an increasing sequence of theories Tn(pB-NRCZT) with the confluence property.

**2.2) B-NRCZT theories**

Definition: let B-NRCZTn be the following sets of resolution rules:
B-NRCZT0: ECP (elementary constraints propagation) (no unsolved puzzle can be solved here)
B-NRCZT1_0: Naked and Hidden Singles
pB-NRCZT1: rules for nrczt-braids of length 1 (equivalent to elementary row-block and column-block interactions - see the subsumption page)
B-NRCZT2: Naked, Hidden and Super-Hidden Pairs + rules for nrczt-braids of length 2
B-NRCZT3: Naked, Hidden and Super-Hidden Triplets + rules for nrczt-braids of length 3

B-NRCZT4: Naked, Hidden and Super-Hidden Quads + rules for nrczt-braids of length 4
For n>4: B-NRCZTn: rules for nrczt-braids of length n

(Super-Hidden = Fish)

Definition: for each each n ≥ 0, the resolution theory Tn(B-NRCZT) is the set of resolution rules at B-NRCZT levels from 0 to n, i.e. T(B-NRCZTn) = B-NRCZT0 + B-NRCZT1_0 + B-NRCZT1 + ... B-NRCZTn.
All these Tn(B-NRCZT) theories have the confluence property and are stable for confluence. This is an easy consequence of the property of stability under confluence for Tn(Subset) and Tn(pB-NRCZT).

The **B-NRCZT rating** of a puzzle P is defined as the smallest n such that P can be solved within Tn(B-NRCZT).
The B-NRCZT rating has all the good properties one can expect of a rating:`
- it is defined in a purely logical way, independent of any solver;
- it is invariant under symmetry and supersymmetry;
- it is based on an increasing sequence of theories Tn(B-NRCZT) with the confluence property.

**3) NRCZT-WHIP THEORIES**

The situation for whips is more complex. To make it short: strictly speaking, whip resolution theories don't have the confluence property, but they almost have it statistically.

**3.1) pNRCZT theories**
Definition: let pNRCZTn be the following sets of resolution rules:
p-NRCZT0: ECP (elementary constraints propagation) (no unsolved puzzle can be solved here)
pNRCZT1_0: Naked and Hidden Singles
pNRCZT1: rules for nrczt-whips of length 1 (equivalent to elementary row-block and column-block interactions - see the subsumption page)
....
pNRCZTn : rules for nrczt-whips of length n.

Definition: for each each n ≥ 0, the resolution theory Tn(pNRCZT) is the set of resolution rules at pNRCZT levels from 0 to n, i.e. T(pNRCZTn) = pNRCZT0 + pNRCZT1_0 + pNRCZT1 + ... pNRCZTn.

The **pNRCZT rating** of a puzzle P is defined as the smallest n such that P can be solved within Tn(pNRCZT). A puzzle P has pNRCZTn rating n if it can be solved using only whips of length no more than n but it cannot be solved using only whips of length strictly smaller than n.
The pNRCZT rating has the following good properties one can expect of a rating:
- it is defined in a purely logical way, independent of any solver;
- it is invariant under symmetry and supersymmetry.

**3.2) NRCZT theories**

Definition: let NRCZTn be the following sets of resolution rules:
NRCZT0: ECP (elementary constraints propagation) (no unsolved puzzle can be solved here)
NRCZT1_0: Naked and Hidden Singles
NRCZT1: rules for nrczt-whips of length 1 (equivalent to elementary row-block and column-block interactions - see the subsumption page)
NRCZT2: Naked, Hidden and Super-Hidden Pairs + rules for nrczt-whips of length 2
NRCZT3: Naked, Hidden and Super-Hidden Triplets + rules for nrczt-whips of length 3
NRCZT4: Naked, Hidden and Super-Hidden Quads + rules for nrczt-whips of length 4
For n>4: NRCZTn: rules for nrczt-whips of length n

(Super-Hidden = Fish)

Definition: for each each n ≥ 0, the resolution theory Tn(NRCZT) is the set of resolution rules at NRCZT levels from 0 to n, i.e. T(NRCZTn) = NRCZT0 + NRCZT1_0 + NRCZT1 + ... NRCZTn.

The **NRCZT rating** of a puzzle P is defined as the smallest n such that P can be solved within Tn(NRCZT).
The NRCZT rating has the good following properties one can expect of a rating:
- it is defined in a purely logical way, independent of any solver;
- it is invariant under symmetry and supersymmetry.

**3.3) An example of non-confluence for whips**
Unfortunately, neither the Tn(pNRCZT) nor the Tn(NRCZT) theories strictly have the confluence property.
See the example in the next post

**3.4) Statistical almost confluence of the whip theories**

As is very often the case in Sudoku, a property that is not strictly valid becomes almost valid when considered from a statistical point of view.

pB-NRCZT is always smaller than pNRCZT. The difference between the 2 ratings is an upper bound for the measure of non confluence of whip theories.
In practice, it is smaller only in fewer than 3 cases in 1000. And it is smaller by more than 1 in fewer than 1 case in 10,000.

Moreover, there is a difference between the 2 ratings that can be assigned to a problem of non confluence in fewer than 1 in 10,000 puzzles.
This last estimation is an imprecise upper bound, because I have to check manually all the cases where a discrepancy appears between pB-NRCZT and pNRCZT, which puts limits on the number of cases I can study in detail.

**4) ZT-BRAID(FP) THEORIES**

It can easily be shown that if the FP family is stable for confluence, then the naturally defined Tn(BRAID(FP)) theories have the confluence property. (Here, as usual, for each n, the n in Tn defines the maximal length of the braids(FP) in Tn.) In particular, all the Tn(braid(Subset)) have the confluence property.

[Edit 01/07/10: as noted by Mauricio in a PM, nrcz-chain theories have the confluence property.
It is also true of nrc-chains and all the 2D counterparts.
This is an easy consequence of reversibility.]

Last edited by denis_berthier on Thu Jan 07, 2010 7:04 pm; edited 2 times in total

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