NTCIR-11 Math-2 Task Overview

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1 Introduction & Motivation for Math-2 Task

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- Mathematics plays a fundamental role in Science, Technology, and Engineering (learn from Math, apply for STEM)
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  - 50 million science articles in 2010 [Jin10] with a doubling time of 8-15 years [Lvl10]

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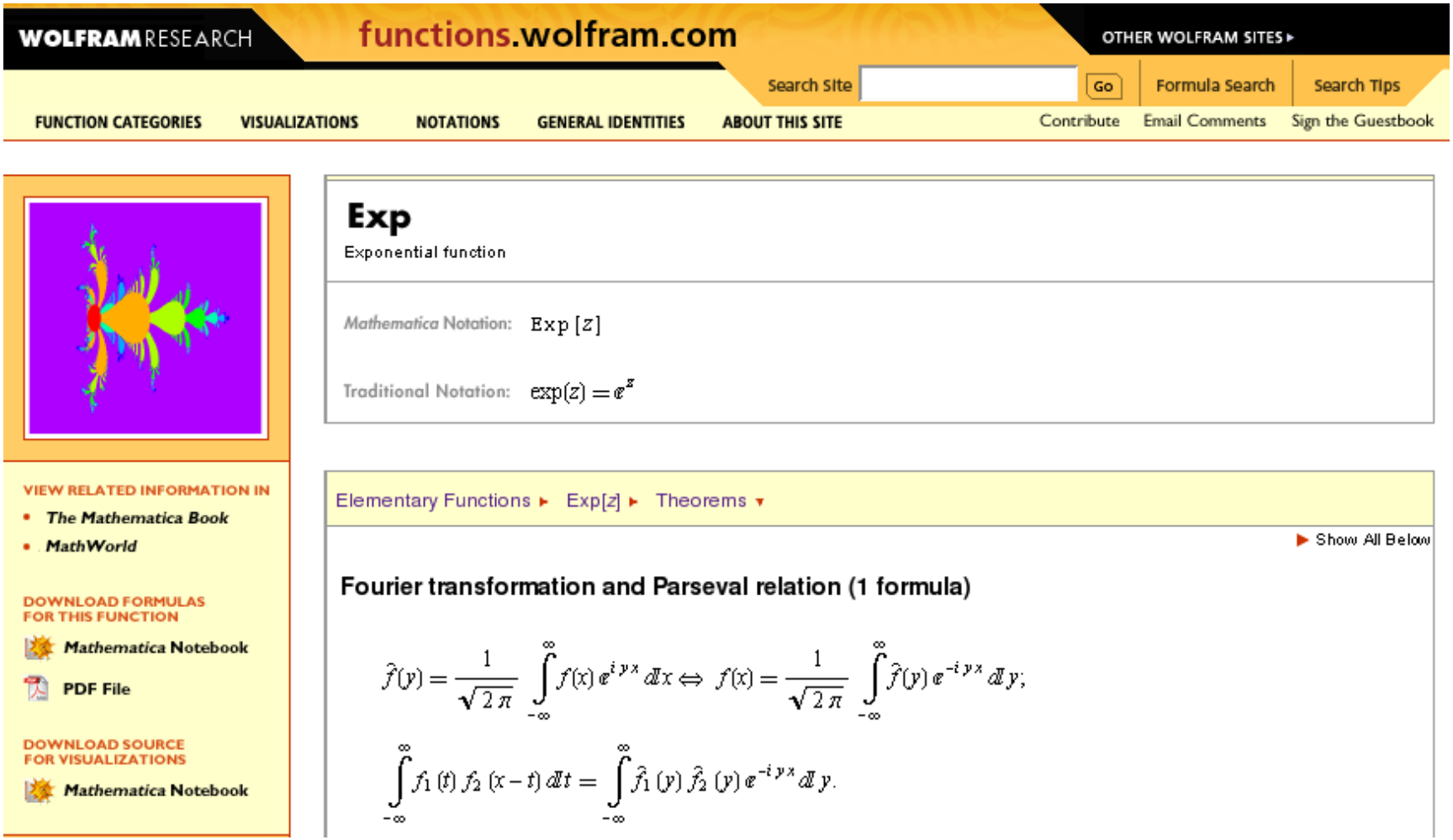
  - Even in the Renaissance, polymaths like Leonardo de Vinci were a rare exception.
- We need IR support to deal with this! ($\leadsto$ NTCIR-11 Math-2 Task)

Mathematics Resources on the Web

- **Example 1.1 (The Wolfram Functions Site)** contains $\geq$ 307k Formuae



Applications of Math Information Retrieval

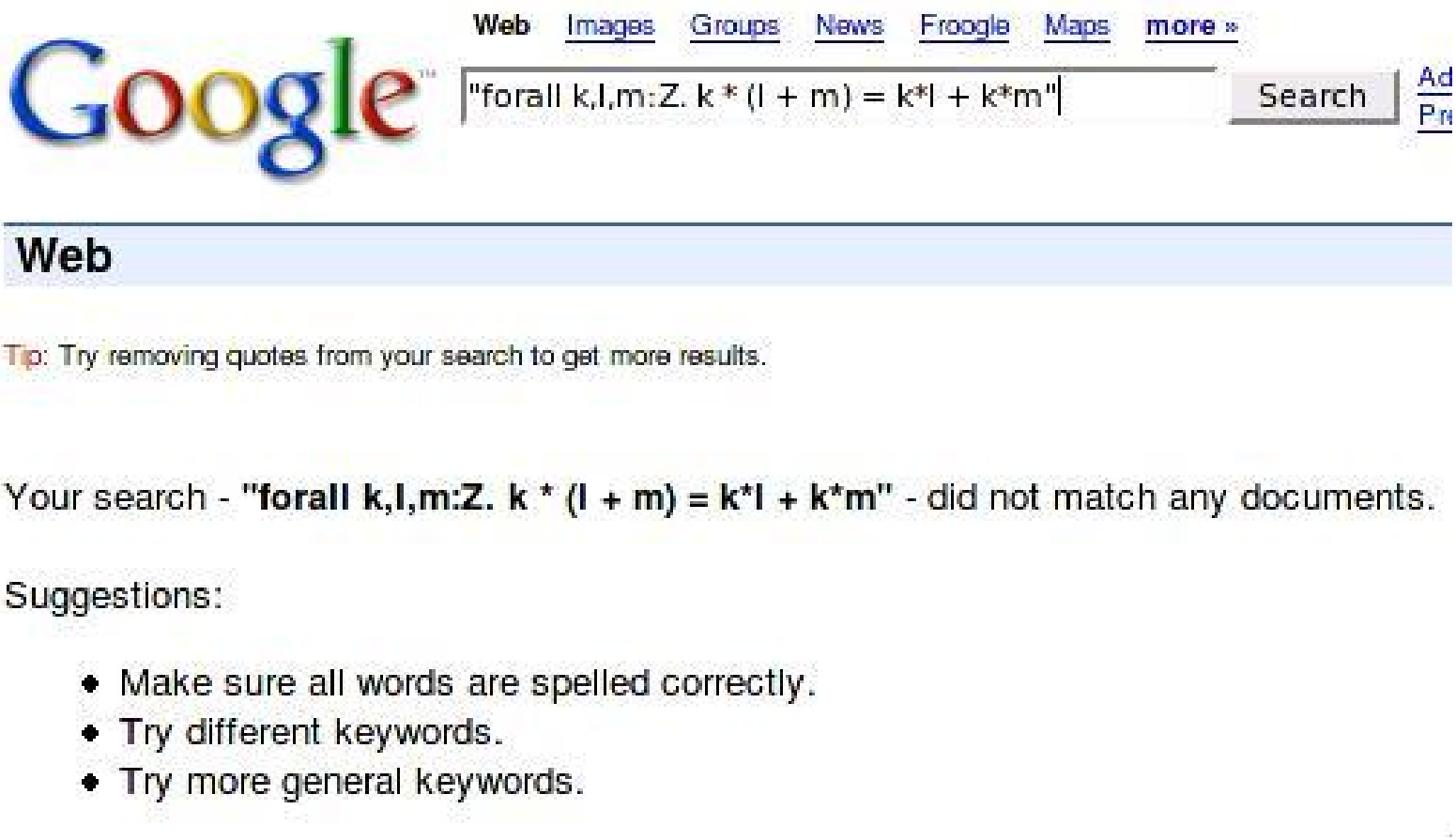
- Potential Applications (some in prototype state)
  - Literature search/Related Work (where have I seen this before?)
  - Applicable Theorem Search (I am stuck in a derivation)
  - Plagiarism detection (not just for the humanities)
  - Formulae in Excel spreadsheets (are just formulae as well)
  - Computations/Documentation in mathematical/symbolic software
  - time series search (e.g. via polynomial interpolations)
- Production systems in math information systems
  - MIAS in EU-DML, MathWebSearch in Zentralblatt Math

More Mathematics on the Web

- The Connexions project (http://cnx.org)
- Wolfram Inc. (http://functions.wolfram.com)
- Eric Weisstein's MathWorld (http://mathworld.wolfram.com)
- Digital Library of Mathematical Functions (http://dlmf.nist.gov)
- Cornell ePrint arXiv (http://www.arxiv.org)
- Zentralblatt Math (http://www.zentralblatt-math.org)
- . . . Engineering Company Intranets, . . .
- Question: How will we find content that is relevant to our needs
- Idea: try Google (like we always do)
- Sicenario: Try finding the distributivity property for $\mathbb{Z}$

$$(\forall k, l, m \in \mathbb{Z}.k \cdot (l + m) = (k \cdot l) + (k + m))$$

Searching for Distributivity



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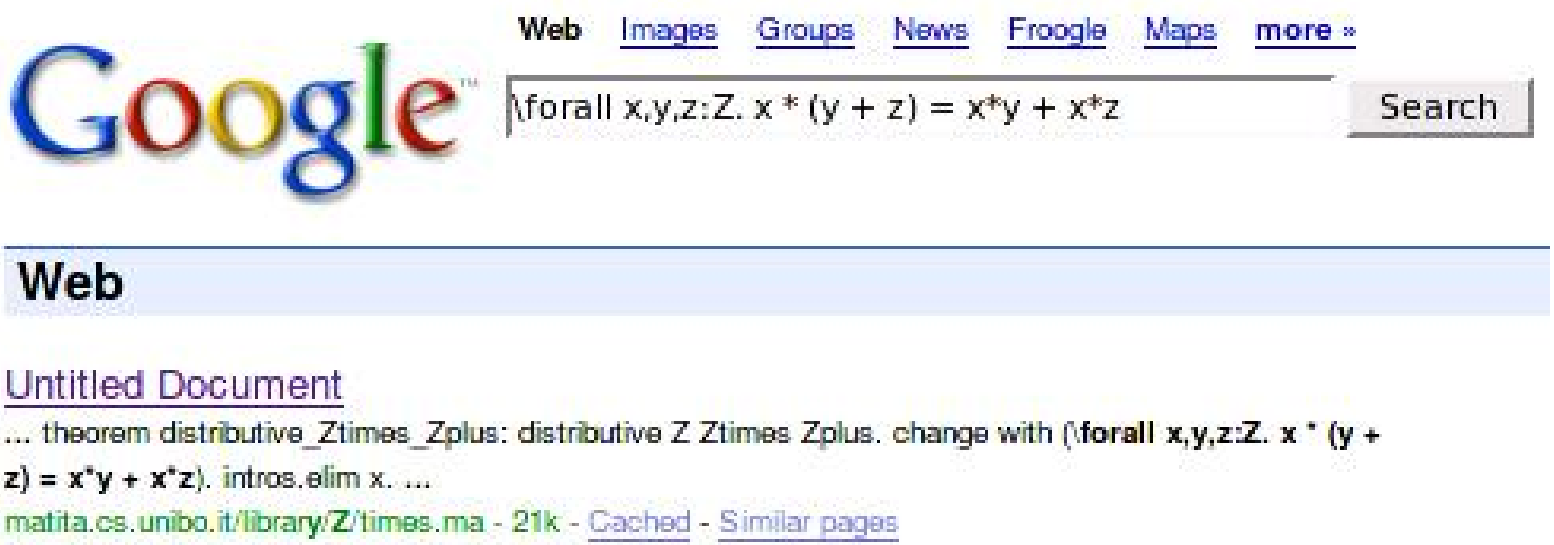
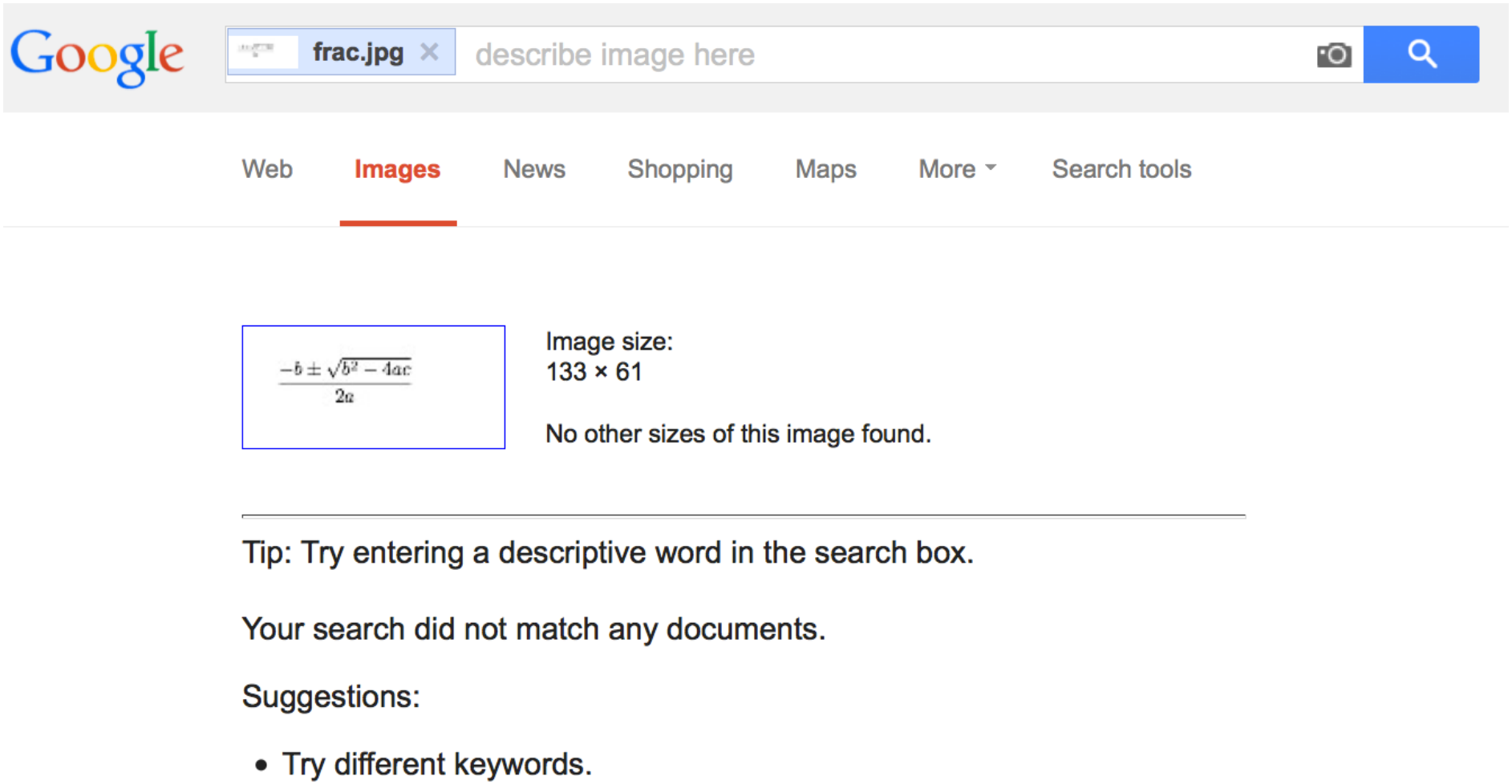


Searching for Distributivity

Does Image Search help?

- Math formulae are visual objects, after all (let's try it)



Of course Google cannot work out of the box

- Formulae are not words:
  - a, b, c, k, l, m, x, y, and z are (bound) variables.
    (do not behave like words/symbols)
  - where are the word boundaries for "bag-of-words" methods?

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- Idea: Need a special treatment for formulae (translate into "special words")
  Indeed this is done ([MY03, MM06, LM06, MG11])
  ...and works surprisingly well (using Lucene as an indexing engine)
- Idea: Use database techniques (extract metadata and index it)
  Indeed this is done for the `Coq`/`HELM` corpus ([AGC+06])
- Idea: Use Automated Reasoning Techniques
  (Term Indexing [Nor06, KŞ06, KMP12])
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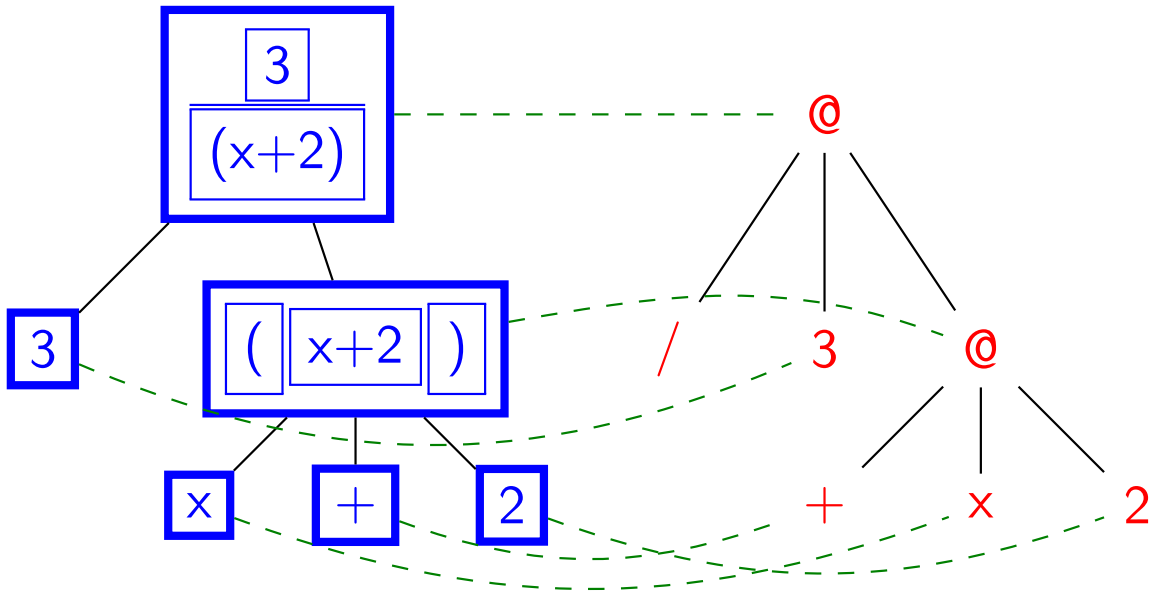
  (Term Indexing [Nor06, KŞ06, KMP12])
- Idea: Use standard IR techniques (Learn from the NTCIR crowd?)
- Which one is best?: We do not really know, evaluation is very difficult
- Future: maybe even mix/integrate the respective best features (once we know)

Math Markup e.g. in MathML and LaTeX

- MathML3 is a W3C Recommendation for representing Formulae [ABC+10]
- Idea: Combine the presentation and content markup and cross-reference



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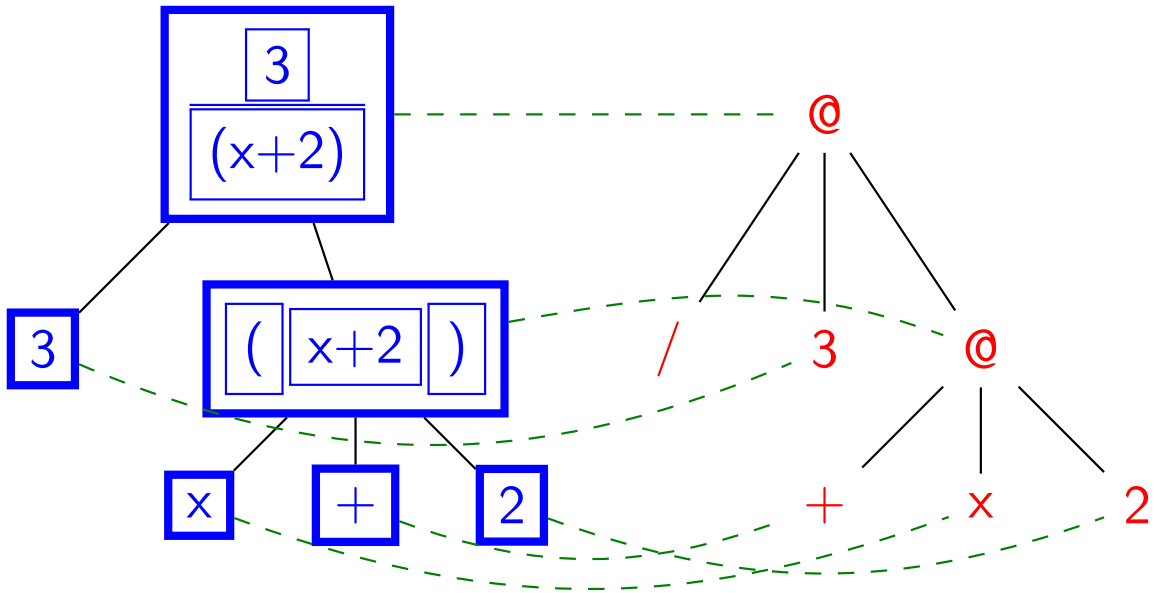

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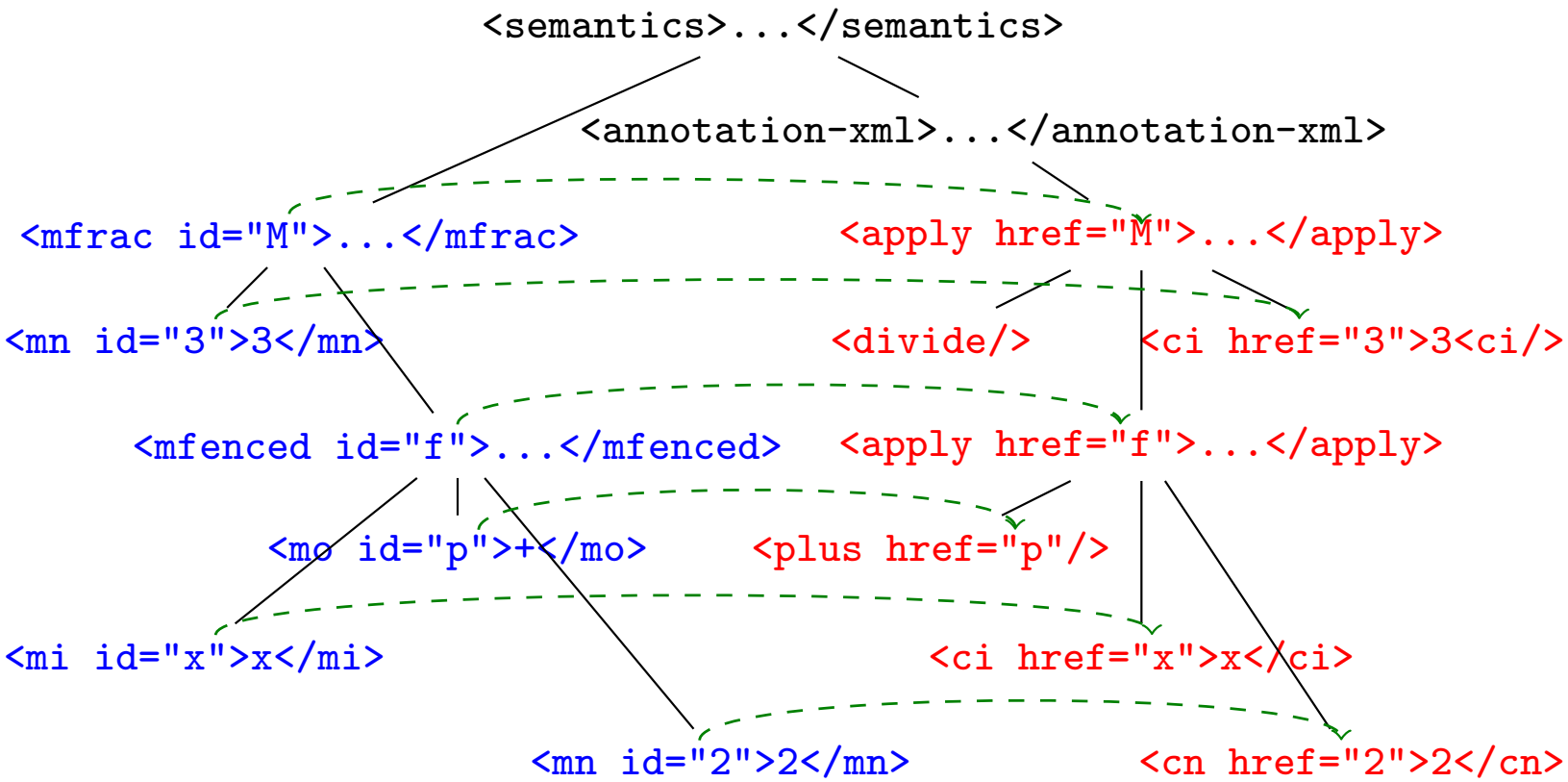
  (click on presentation, follow link and copy content)
- But: Formulae are mostly written in LaTeX, e.g. `\frac{3}{(x+2)}`
- Solution: Write LaTeX, convert to HTML5≙ HTML+MathML+SVG

Parallel Markup Markup in MathML

- Concrete Realization in MathML: `semantics` element with presentation as first child and content in `annotation-xml` child

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