INDICES OF POWER
IOP 2.0 (Release 5/05)

© 1996-2005 Thomas Bräuninger and Thomas König
Department of Politics and Management
University of Konstanz, Germany

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Updates in Release 5/05 (10/10/2005): winning coalitions (options Shapley/inclusiveness and Banzhaf) or minimal winning coalitions (option Public good index) may be written to both the screen and an ASCII file with extension "oou"
Updates in Release 4/04 (08/08/2004): This new release includes a "multiple weights" option that allows to specify games where actors have more than one weight. An example is the European Union's Council of Ministers where according to the voting rules specified in the Nice Treaty, members have two weighted and one unweighted vote. IOP allows for calculating power indices for these seettings by the option "multiple weights" where up to 4 weights can be specified. In addition, the maximum number of actors is decreased to 50 per chamber.
Updates in Release 3/03: (a) sum of voting weights may be as large as 2147483647
Updates in Release 2/01: (a) double-weight routine implemented for all indices; (b) option for reporting winning and minimal winning coalitions implemented; (c) maximum number of actors increased to 80 per chamber; (d) various bugs fixed

IOP calculates various voting power indices for simple voting games in single- and multi-chamber systems with actors having weighted and/or unweighted votes including:
  Shapley-Shubik index (Shapley/Shubik 1954)
  Inclusiveness index (Bräuninger 1996, König/Bräuninger 1997a, 1997b, 1998, 2001)
  Non-normalized and **normalized Banzhaf index** (Banzhaf 1965, Dubey/Shapley 1979)
  Public good index (Holler 1982)
  Member bargaining power index (Brams/Fishburn 1995)
  Deegan-Packel index (Deegan/Packel 1978)
  Decision probability index (Coleman 1971)

IOP can also be used to report winning coalitions or minimal winning coalitions in simple voting games (use the option "screen control" when calculating power indices).

Simple voting games. Simple voting games have two properties: First, every actor votes with Yes or No. Second, collective decisions depend on meeting a threshold, i.e. a certain number of actors or a certain sum of voting weights. Simple voting games distinguish between winning and losing coalitions, and they satisfy monotonicity by assuming that winning coalitions remain winning when additional members join the coalition.

Single- and multi-chamber systems. Single-chamber systems can be conceived as simple games. In a group of 100 actors, e.g., simple majority rule sets the threshold to 51 actors defining the range of all winning coalitions from 51 to 100 actors. Multi-chamber systems can be conceived as (simple) subgames that are combined in the compound game. In a two-chamber system with 100 actors in the first and 435 actors in the second chamber, e.g., the bicameral range of all winning coalitions is defined on 51 to 100 actors of the first and 218 to 435 actors of the second chamber, if the compound game requires simple majority in both chambers. If the compound game requires two-third majorities, the bicameral range of all winning coalitions is defined on 67 to 100 actors in the first and 290 to 435 actors in the second chamber.

Note: In games with weighted votes IOP sets limits to a maximum of 10 chambers each consisting of a maximum of 50 actors. Voting weights are integers, the sum of votes shall not exceed 2147483647. Note that any additional actor approximately doubles computation time when using weighted votes. If you wish to calculate weighted voting games with more than 50 actors per chamber, please contact the author.

for information, please visit this page
(http://www.tbraeuninger.de/IOP.html)
or contact:
thomas.braeuninger@uni-mannheim.de

INSTALLATION INSTRUCTIONS

IOP 2.0 is running with MS-DOS 5.0 or higher for IBM PC or compatible. If you are working with Microsoft Windows 95/98, NT 4.0 or higher, 2000 or XP, IOP will use the MS-DOS emulation.

To install IOP, do the following:

- Create and/or change to the directory c:\iop, or to any other directory on your hard disk drive, in which to install IOP
- Download a packed copy of IOP from the URL
  http://www.tbraeuninger.de/IOP.html
  and unpack the file iop202.zip to the directory c:\iop (or the selected directory).
- If you wish to call IOP from any directory using MS-DOS, set the PATH command in the autoexec.bat to the directory
      c:\iop
  (or any selected directory). Then, reboot. You can now call IOP typing: iop (ENTER)
 Using Microsoft Windows just double-click on IOP.EXE

The initialization file iop.ini is a ASCII file containing parameters of the IOP environment. You can edit iop.ini with any ASCII editor. Parameters include:

outputtab	provide an unformated output file name.ouu (0=no, 1=yes) (default=0)
precision	precision of numbers in unformated output file name.ouu (default=4)
backcol	background color (0 to 15) (default=1)
menuecol	menu color (0 to 15) (default=8)
textcol	text color (0 to 15) (default=15)
weights	allow sum of voting weights to be as large as 2147483647

PROGRAM DESCRIPTION

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IOP's data menu

Here you can create IOP input files defining the structure of the simple game, list input and output files, send files to printers and exit from IOP

_____
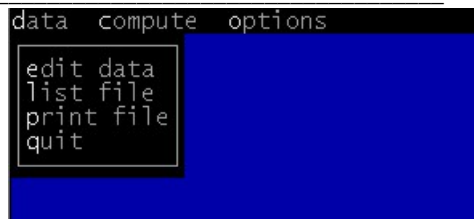
> edit data

Creates new and edits existing data files.

1. Insert name of the data file (without extension; IOP uses standard extension "inp" when defining input files)
2. Specify whether you have actors with weighted or unweighted votes
3. Insert the number of subgames (or chambers)
4. Insert the number of actors for each subgame
5. For weighted games, only, insert the actors' voting weights.

The data file is saved with the IOP input file extention "inp" as "name.inp" on the current path.

> list data

Shows input and output data files on the screen. Insert the name of the data file including the extension ".inp" or ".out".
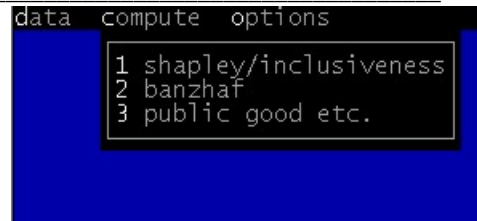
> print file

Prints input and output data files on the standard printer. Insert the name of the data file including the extension ".inp" or ".out".

> quit

Exit from IOP

_____

IOP's compute menu

Here you can compute various prominent voting power indices

```
data  compute  options
    1 shapley/inclusiveness
    2 banzhaf
    3 public good etc.
```

_____

> shapley/inclusiveness

Computes Shapley-Shubik and inclusiveness indices. Having inserted the name of the data file IOP offers different options depending on whether the data consist of unweighted or weighted votes.

Games with unweighted votes

1. IOP shows a data summary, e.g. in the US Congress game:

```
data file: usa
datastructure:          unweighted
number of subgames:     3
cummulated weights:     1 100 435
```

2. Now, specify the thresholds that define winning coalitions. Insert the number of "winsets". IOP combines two and more winsets using the "or"-operator, e.g.:

```
number of winsets:      2
```

3. For each win set insert the quota that defines a winning coalition, e.g.

```
winset 1:
threshold subgame 1:    1
threshold subgame 2:    51
threshold subgame 3:    218
winset 1:               [1,1] * [51,100] * [218,435]

winset 2:
threshold subgame 1:    1
threshold subgame 2:    51
threshold subgame 3:    218
winset 2:               [0,1] * [67,100] * [290,435]
```

Note, since simple games have the monotonicity property guaranteeing that winning coalitions remain winning when additional actors join, the winning interval of each subgame ranges from the subgame's threshold to the total number of actors (in games with unweighted votes) or to the total number of votes (in games with weighted votes).

4. Control the processing of IOP with

```
screen control (y/n): y
```

Games with weighted votes

1. IOP first asks for the name of the (primary) input data file that contains the (the first) voting weights of actors. You then have to specify whether actors have one (standard) or more types of weighted votes (multiple weights). To obtain, for instance, power indices for the European Council of Ministers set up a game with weighted votes. For the EU-25 the Pre-Treaty of Nice rules apply from the time of accession (May 2004) until November 2004, i.e. qualified majority voting with weighted votes and the 71% majority threshold.

```
primary data file: eu25old
```

```
        version: standard(1), multiple weights(2) (1/2): 1

        datastructure:          weighted
        number of subgames:     1
        cumulated weights:      124

        number of winsets:      1
        winset 1:
        threshold subgame 1:    89
        winset 1:               [89,124]

        overall threshold (number of players): 0
```

From November 2004 to October 2009, the provisions of the Nice Treaty apply. The Nice Treaty reweighs Council votes and adds two additional criteria for majority voting. It specifies (i) a 72.2% quota for states weighted votes in the Council (232 of 321 weighted votes), (ii) a 50% member threshold (13 of 25 states) and (iii) a 62% population threshold. To analyse this setting define two input files, one containing the weighted votes, the other containing the population figures, and use the option "multiple weights".

```
        primary data file: eu25nice

        version: standard(1), multiple weights(2) (1/2): 2

        datastructure:          weighted
        number of subgames:     1
        cumulated weights:      321

        number of winsets:      1
        winset 1:
        threshold subgame 1:    232
        winset 1:               [232,321]

        overall threshold (number of players): 13

        second data file: pop25

        datastructure:          weighted
        number of subgames:     1
        cumulated weights:      3753

        number of winsets:      1
        winset 1:
        threshold subgame 1:    2793
        winset 1:               [2793,4505]

        screen control (y/n): y
```

Note that in weighted games the "overall threshold" option is used to specify a further threshold that applies to all subgames (chambers). Otherwise, type 0 for the overall threshold.

2. In order to obtain a list of all winning coalitions chose the options

```
        screen control (y/n): y
        report winning coalitions (y/n): y
```

Note that screen control at least doubles computation time. In the submenue "public good etc." (see below) all minimal winning coalitions are reported.

Results are shown on the screen. Columns in the output refer to:

subgame	running number of subgame
player	running number of player
weight	weight of player
SS	Shapley-Shubik index of player
II	inclusiveness index of player
winsets	total number of winning coalitions the player is member of
sum	sum of Shapley-Shubik indices of subgame/all players
winning coalitions	total number of winning coalitions

decision probability	Coleman's decision probability

Results are also saved in the output file "name.out". If the parameter "outputtab" in the initialization file iop.ini is set to 1, a further, unformated output file "name.ouu" is saved with Shapley-Shubik indices in the first and inclusiveness indices in the second column.

> banzhaf

Computes non-normalized and normalized Banzhaf indices. Results are shown on the screen and saved in output files. Columns in the output refer to:

| subgame	running number of subgame
player	running number of player
weight	weight of player
NNBZ	non-normalized Banzhaf index of player
NBZ	normalized Banzhaf index of player
sum	sum of Banzhaf index of subgame/all players
mean	mean power over all players
winning coalitions	total number of winning coalitions

> public good etc.

Computes public good, member bargaining and Deegan-Packel indices. Results are shown on the screen and saved in output files. Columns in the output refer to:

subgame	running number of subgame
player	running number of player
weight	weight of player
PGI	public good index of player
MBP	member bargaining power index of player
DPI	Deegan-Packel power index of player
sum	sum of power of subgame/all players
mean	mean power over all players
minimal winning coalitions	total number of minimal winning coalitions

_____

IOP's option menu

Here you can change default settings of IOP and list a help file

_____
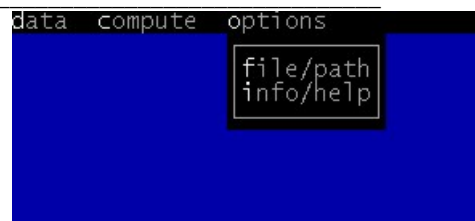
> file/path

If you miss inserting a name when asked for a input or output file IOP uses "default.inp" and "default.out" as the default name. This submenue allows you to change the default name. You can also change the current path IOP uses for reading and writing files.

> help/info

Shows a HELP/INFO file

_____

EXAMPLE 1: Unicameral European Council of Ministers of the EU-15

In the pre-Nice European Council of Ministers, the then 15 member states were provided with weighted votes for qualified majority decision making with minority rule.
Insert the data that define the structure of this unicameral voting game in the submenu edit data (input data file eu15old.inp is attached to the IOP package):

```
                                                            IOP 2.0

  data file: eu

  unweighted/weighted votes (0/1): 1
  number of subgames: 1
  number of players (subgame 1): 15
    weight player 1: 10
    weight player 2: 10
    weight player 3: 10
    weight player 4: 10
    weight player 5: 8
    weight player 6: 5
    weight player 7: 5
    weight player 8: 5
    weight player 9: 5
    weight player 10: 4
    weight player 11: 4
    weight player 12: 3
    weight player 13: 3
    weight player 14: 3
    weight player 15: 2


press any key
```

According to Art. 148,2b of the European Community Treaty the Council decided with a qualified majority of 62 votes with the additional provision that the majority encompasses at least 10 member states. Hence, the range of the win set is 62 to 87 with the additional minority rule of 10 actors. To calculate Shapley-Shubik and inclusiveness indices, select submenu shapley/inclusiveness and insert the thresholds:

```
                                                            IOP 2.0

  shapley/inclusiveness

  data file: eu


  datastructure:          weighted
  number of subgames:     1
  cumulated weights:      87

  number of winsets:      1
  winset 1:
  threshold subgame 1:    62
  winset 1:               [62,87]

  overall threshold (number of players): 10

  screen control (y/n): y_
```

The output lists Shapley-Shubik (SS) and inclusiveness (II) indices for all actors. The last column (winsets) lists the number of winning coalitions an actor is member of. Finally, the total number of winning coalitions and Coleman's decision probability are reported.

```
                                                              IOP 2.0

data file: eu
win set    1: [62,87]
overall threshold: 10

subgame  player  weight        SS        II                winsets
-------------------------------------------------------------------
       1       1     10  0.111405  0.849024 1.95700000000000000E+0003
       1       2     10  0.111405  0.849024 1.95700000000000000E+0003
       1       3     10  0.111405  0.849024 1.95700000000000000E+0003
       1       4     10  0.111405  0.849024 1.95700000000000000E+0003
       1       5      8  0.091975  0.793926 1.83000000000000000E+0003
```

and so on ....

```
                                                              IOP 2.0

       1       5      8  0.091975  0.793926 1.83000000000000000E+0003
       1       6      5  0.056310  0.709761 1.63600000000000000E+0003
       1       7      5  0.056310  0.709761 1.63600000000000000E+0003
       1       8      5  0.056310  0.709761 1.63600000000000000E+0003
       1       9      5  0.056310  0.709761 1.63600000000000000E+0003
       1      10      4  0.047619  0.679826 1.56700000000000000E+0003
       1      11      4  0.047619  0.679826 1.56700000000000000E+0003
       1      12      3  0.038928  0.648590 1.49500000000000000E+0003
       1      13      3  0.038928  0.648590 1.49500000000000000E+0003
       1      14      3  0.038928  0.648590 1.49500000000000000E+0003
       1      15      2  0.025142  0.606941 1.39900000000000000E+0003
subgame       1:          1.000000
sum of all:               1.000000

winning coalitions:          2305
decision probability:    0.070343

time1: 18/11/2000 12:12:23    time2: 18/11/2000 12:12:27


press any key
```

EXAMPLE 2: The US three-Chamber System

The US Congress has of two chambers, the 435-member House and the 100-member Senate. Moreover, the President plays a formal role in legislation having the right to veto any legislative act. Therefore, we can think of the US legislative game as a three-chamber system with one President, 100 senators, and 435 representatives, all having unweighted votes.

Insert data in submenu edit data (input data file usa.inp is attached to the IOP package).

The passing of a bill requires the approval of either a simple majority in both chambers (218 representatives and 51 senators) and the President's consent, or, if the bill is vetoed by the President, two-third majorities in both chambers (290 representatives and 67 senators).

Calculate Shapley-Shubik and inclusiveness indices in submenu shapley/inclusiveness:

```
                                                              IOP 2.0

data file: usa
win set    1: [1,1] * [51,100] * [218,435]
win set    2: [0,1] * [67,100] * [290,435]

subgame  player  weight        SS        II                winsets
-------------------------------------------------------------------
       1       i      1  0.160470  1.000000 2.58803042285302796E+0160
subgame       1:          0.160470
       2       i      1  0.004374  0.543236 1.40591056079475420E+0160
subgame       2:          0.437418
       3       i      1  0.000924  0.519139 1.34354704544209870E+0160
subgame       3:          0.402112
sum of all:               1.000000

winning coalitions:      2.58803042285303582E+0160
decision probability:    0.115051

time1: 18/11/2000 12:57:59    time2: 18/11/2000 13: 1:27


press any key
```

EXAMPLE 3: Post-Nice European Council of Ministers in the EU-15

The Nice Treaty established new thresholds for decision-making in the Council in the EU of the former 15 member states. According to Article 3, 1a(i)-(ii) of the Nice of Treaty's Protocol on the Enlargement of the European Union (SN 1247/01EN, Brussels 30. January 2001):

> "Acts of the Council shall require for their adoption at least 169 votes in favour cast by a majority of the members where this Treaty requires them to be adopted on a proposal from the Commission. In other cases, for their adoption acts of the Council shall require at least 169 votes in favour, cast by at least two-thirds of the members." When a decision is to be adopted by the Council by a qualified majority, a member of the Council may request verification that the Member States constituting the qualified majority represent at least 62% of the total population of the Union. If that condition is shown not to have been met, the decision in question shall not be adopted."

1. Generate a data files that contains weighted votes in the Council:

```
                                                          IOP 2.0
data file: eu15

unweighted/weighted votes (0/1): 1
number of subgames: 1
number of players (subgame 1): 15
  weight player 1: 29
  weight player 2: 29
  weight player 3: 29
  weight player 4: 29
  weight player 5: 27
  weight player 6: 13
  weight player 7: 12
  weight player 8: 12
  weight player 9: 12
  weight player 10: 10
  weight player 11: 10
  weight player 12: 7
  weight player 13: 7
  weight player 14: 7
  weight player 15: 4

press any key
```

2. Generate a data files that contains population weights:

```
                                                          IOP 2.0
data file: bev15

unweighted/weighted votes (0/1): 1
number of subgames: 1
number of players (subgame 1): 15
  weight player 1: 820
  weight player 2: 592
  weight player 3: 590
  weight player 4: 576
  weight player 5: 394
  weight player 6: 158
  weight player 7: 105
  weight player 8: 102
  weight player 9: 100
  weight player 10: 89
  weight player 11: 81
  weight player 12: 53
  weight player 13: 52
  weight player 14: 37
  weight player 15: 4

press any key
```

3. In order to obtain, e.g., public good power indices select the option double-weight in the submenue 'public good' and specify the
(i) the first data file and the first threshold (71% of Council weighted votes)

(ii) the overall threshold (simple majorty number of member states)
(iii) the second data file and the second threshold (62% of total population)

```
                                                              IOP 2.0
 data file: eu15

 version: standard(1), double-weight(2) (1/2): 2
 datastructure:         weighted
 number of subgames:    1
 cumulated weights:     237

 number of winsets:     1
 winset 1:
 threshold subgame 1:   169
 winset 1:              [169,237]

 overall threshold (number of players): 8
```

```
 second data file: bev15

 datastructure:         weighted
 number of subgames:    1
 cumulated weights:     3753

 number of winsets:     1
 winset 1:
 threshold subgame 1:   2327
 winset 1:              [2327,3753]

 screen control (y/n): n_
```

4. IOP reports
    (i)   input file names
    (ii)   public good (PGI), member bargaining power (MBP) and Deegan-Packel power indices (DPI)
    (iii) the total number of minimal winning coalitions

```
                                                              IOP 2.0
 data file: rat15n
 win set     1: [169,237]
 overall threshold: 8
 double-weight file: bev15n

 subgame   player   weight      PGI       MBP       DPI
 --------------------------------------------------------
      1        1       29    0.084161  0.825000  0.085527
      1        2       29    0.082819  0.811842  0.084431
      1        3       29    0.082819  0.811842  0.084431
      1        4       29    0.082819  0.811842  0.084431
      1        5       27    0.081611  0.800000  0.082985
      1        6       13    0.066040  0.647368  0.065594
      1        7       12    0.062282  0.610526  0.061998
      1        8       12    0.062282  0.610526  0.061998
      1        9       12    0.062282  0.610526  0.061998
      1       10       10    0.060537  0.593421  0.059815
      1       11       10    0.060537  0.593421  0.059815
      1       12        7    0.056107  0.550000  0.054914
      1       13        7    0.056107  0.550000  0.054914
```

```
      1       11       10    0.060537  0.593421  0.059815
      1       12        7    0.056107  0.550000  0.054914
      1       13        7    0.056107  0.550000  0.054914
      1       14        7    0.056107  0.550000  0.054914
      1       15        4    0.043490  0.426316  0.042236
 sum of subgame  1:           1.000000  9.802632  1.000000
 sum of all:                  1.000000  9.802632  1.000000
 mean:                        0.066667  0.653509  0.066667

 minimal winning coalitions:             760

 time 1: 8/2/2001 15:28:41    time 2: 8/2/2001 15:33:26


 press any key
```

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Thomas Bräuninger